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AGGRESSION AS A REINFORCER IN SIAMESE FIGHTING FISH

A Repetition and a Control

by

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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Aggression As A Reinforcer In Siamese Fighting Fish: A Repetition And A Control", submitted by Stephen Robert Goldstein in partial fulfillment of the requirements for the degree of Master of Science.

Abstract

Two experiments were conducted to corroborate the finding by Thompson (1963) that the stimuli which evoke aggression in male Siamese Fighting Fish could act as a reinforcer. Subject's mirror image was used as the reinforcer to be tested, and the number of responses emitted by S was used as an index of the effectiveness of the reinforcer. In the first experiment, 2 groups of 6 Ss each were tested in 15 min. distributed practice sessions in which reward presentation was response contingent for the experimental group, and determined by a randomly generated temporal sequence for the control group. Conditioning was not obtainable and reliable differences were not found between groups. This necessitated a more exact replication of the Thompson demonstration. In this experiment each of 4 Ss were randomly assigned to an experimental group (reward response contingent), a yoked control group (reward not determined by the response), and an operant control group (no reward). Following Thompson, these Ss were maintained in their test chambers where they had constant access to the response manipulandum throughout the 14 day testing period. The results of this experiment confirmed Thompson's original finding. In addition, a discussion of the issues involved in research on aggression was presented along with a discussion of various methodological issues involved in yoked control research.

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CHAPTER ONE

General Orientation

The purpose of this thesis was to repeat a demonstration which purported to show that the stimuli which evoke aggression in male Siamese Fighting Fish could act as a reinforcer of new behavior. In addition, an attempt was made to put this demonstration in both an historical and logical perspective, and to discuss and evaluate certain problems raised by such a demonstration. These three tasks are presented in each of three chapters.

Chapter Two traces the evolution of opinion regarding the origin of aggressive behavior. Briefly, protagonists have maintained on the one hand that aggression is innate, and on the other, that it is learned. The point is made in this chapter that specific issues regarding this controversy have not been formulated in a manner which would provide an adequate test of either hypothesis. It is suggested in this connection that it is probably not necessary to assume that for any given organism the learned-innate distinction represents two mutually exclusive categories of ontogeny.

With an emphasis on the instinctual conception of aggression, it is argued that much aggressive behavior, exhibited by a wide variety of animals, can be classed as Fixed Action Patterns (FAPs): a classification which helps throw light on various issues regarding the origin of aggression. Conceptual similarities are then drawn between the FAP and Hullian drive, and the point is argued that the FAP, like drive, may have reinforcing properties. Since the

point was made that certain forms of aggression are a subclass of FAPs, and since it was also suggested that FAPs may have reward value, it was proposed syllogistically that aggression may be reinforcing. Evaluation of an experiment conducted by Thompson regarding this contention suggested that a repetition of his demonstration with more adequate controls was in order.

Chapter Three is divided into two parts with each portion representing a different experiment. In Experiment I, an attempt was made to replicate, with a modified technique, the Thompson demonstration, and to obtain evidence regarding the exact nature of the reward. Since negative results were obtained, a more exact repetition of the Thompson demonstration, incorporating additional controls, was required. The results of this more exact repetition suggested that, at least for Siamese Fighting Fish, the stimuli which evoke aggressive behavior do in fact act as reinforcers of new behavior, and that these fish will actively seek out situations in which to be aggressive.

Finally, Chapter Four presents a discussion of methodological considerations involved in yoked-control designs (the procedure used in Experiment II). Criticisms of the yoked-control design are presented and counter arguments are advanced which question the tenability of these criticisms. Related to this discussion is a certain misconception about the function of a reinforcer, and this misconception discussed. The chapter ends with a consideration of prospects for future research on aggression and an overall summary of the paper.

CHAPTER TWO

Introduction

Historically, the problem of the origin and nature of aggressive response tendencies has been explained either by reference to innate or instinctual determinants of aggression on the one hand, or by reference to cognitive or learned determinants on the other. The former type of explanation was most prevalent around the end of the last century and early part of the present century through the influence of Darwin, and then somewhat later, Freud. The latter view gained prominence around the outset of World War II when experimental psychologists, who had devoted themselves almost exclusively to learning phenomena, attacked the problem. Since these psychologists thought mainly in terms of learning variables, it was natural for them to look for an explanation of aggression in such terms. At the present time, cognitive conceptions of aggression tend to predominate the literature but there is at the same time a noticable tendency for the pendulum to begin swinging back in the instinct direction (Lorenz, 1956; Tinbergen, 1951). However, before anything further can be said about these perspectives it is necessary to consider in more detail what each position involves.

The Frustration-Aggression Hypothesis

With one or two conspicuous exceptions (Buss, 1961; Lawson, 1965) the most generally accepted model for explaining aggressive behavior

among cognitive theorists is the Frustration-Aggression hypothesis. Originally proposed by a team of research workers (Dollard, Doob, Miller, Mowrer, and Sears, 1939) at the newly founded Yale Institute of Human Relations, the frustration-aggression hypothesis states in its most generally accepted form that; (1) any frustration will increase the probability of occurrence of an aggressive response, and (2) a frustration is a necessary and sufficient condition for the instigation of an aggressive response (or more forcefully, there can be no aggression without there first occurring a frustration). The conception is basically a cognitive one because what is perceived as frustrating is assumed to be the result of experiential or learning phenomena. Not all cognitive theorists however, accept the second assumption of the frustration-aggression hypothesis. Notable among these is Buss (1961) who emphasises that there are antecedents of aggression which are not frustrating, for example noxious stimuli such as attack or threat, as well as aggressive responses that are instrumental in securing a goal object not involving a frustration (Reynolds, Catania, and Skinner, 1963).

The Instinct Conception of Aggression

In general, an instinct conception of aggression maintains that aggressive response tendencies are basically unlearned. Given this generalization, instinct theorists differ as to the origin of aggressive behavior. This difference of opinion neatly divides such theorists into two groups: those who believe that the instigation to aggressive behavior is a driving force entirely

within the organism (Freud, 1959; Lorenz, 1937), and those who believe that aggressive response tendencies are elicited by innately determined external stimuli. For convenience, the first position shall be referred to as the reservoir theory of aggression, and the second as the tropistic theory of aggression. It should also be pointed out that an intermediate position (i.e. between the cognitive and instinctive perspectives), called the epigenetic approach, has also been advanced (Moltz, 1965).

Present Status of the Controversy

A perusal of some of the major theoretical statements concerning this controversy shows the following: (1) that cognitive theorists are somewhat reluctant to accept a tropistic conception of aggression (Kuo, 1930; Allee, 1931; Thorpe, 1956) but will not concede any ground, in fact vigorously deny credibility to, and direct most of their attacks against, the reservoir theory of aggression (Scott, 1958, 1965, p. 62; Berkowitz, 1962, p. 20); (2) that instinct theorists on the other hand, seem to take a less extreme position admitting that learned determinants may strongly influence complex behaviors such as aggression (Moltz, 1965; Eibl-Eibesfeldt, 1961) but at the same time insist upon the validity of innate determinants of aggression; and (3) that among instinct theorists there appears to be no active controversy regarding their differences primarily because the ethological concept of the Fixed Action Pattern (FAP) makes an intermediate position possible and because the psychoanalysts who originally introduced the reservoir theory cease to be active in maintaining or substantiating their formulation.

From the above considerations it is probably safe to conclude that there exists at the present time a rather strong bias against the instinct conception of aggression. This bias is limited primarily to American psychology where instinct conceptions have (with some early exceptions) generally not received a very favorable audience and where the spirit of pragmatism and hence optimism about the future have flourished. These considerations are germane to the aggression controversy because if aggression is biologically rooted, the implications for the future of man (particularly in an atomic age) are dim, while if aggression is experientially rooted, the prospect for a more hopeful future rests with finding and establishing a suitable environment. Whatever the reason for this antagonism, the bias taken here is that the instinct position appears to be tenable and that current evidence either does not refute it or could logically be interpreted as support for the position. Before considering the relevant evidence however, it is essential that the so-called crucial issues be stated in such terms that it is possible to determine precisely what counts as positive or negative evidence for a particular perspective. One probable reason that the issues in this controversy have never been resolved is that this usually has not been done. Two fundamental issues which apparently need restatement are, "Is aggression learned or innate?", and "Is aggression elicited or emitted?"

Is Aggression Learned or Innate?

This issue might be restated as follows: "All aggressive behavior in all species is the result of some learning experience." So phrased it becomes

at once apparent that the terms all aggressive behavior, all species, and learning experience, determine the fate of this issue. Thus for the instinct theorist this means that he must somehow be able to show that aggressive response patterns are genetically encoded and that their translation into behavioral acts occurs in the absence of prior experience with the specific stimulus situation used at the time of testing. If such a demonstration were possible it would warrant a modification of the original statement to the form, "All aggressive behavior in some species is the result of some learning experience", or "Some aggressive behavior in some species is the result of some learning experience".

To see more clearly what this implies, consider first the clause "all aggressive behavior". By its inclusiveness, this clause puts the entire proposition in a vulnerable position because it is only necessary for opponents to demonstrate that one class of aggressive response patterns is unlearned. Granting that such a demonstration is a formidable task, its successful completion would seriously undermine the tenability of the proposition as it now stands. Assuming that the recommended form of change, "Some aggressive behavior ... is learned", applies with equal validity to the alternative formulation, "Some aggressive behavior ... is genetically determined", the question then of what counts as evidence for or against each position is put in a different light. That these considerations are not purely academic is evidenced by the fact that much experimental work has been carried out to demonstrate the inadequacy of the reservoir theory in its more inclusive but less tenable form; a form, by the way, that few instinct theorists endorse. Thus for example Scott (1947) showed that

fighting in mice could be made to occur without the accompanying emotional reactions of hair fluffing and tail rattling and from this concludes that the causal sequence of events leading to fighting does not necessarily depend upon the initiation of an emotional (presumably anger) reaction. However, the fact that it is possible to train mice to fight without the apparent emotional reaction of hair fluffing and tail rattling only establishes that success in fighting (the training procedure used) reduces the intensity of the behavioral response measures, not that it eliminates an initial emotional reaction. This notwithstanding, the experiment fails to provide a crucial test of the issue because even if it is granted that animals can be trained to fight without apparent emotion, it in no way mitigates the idea that the initiation of "natural" aggressive response tendencies is internally activated. By way of analogy, it might be possible to teach an animal to emit chewing responses in order to procure reinforcement for the satiation of some existing drive state, say sex deprivation, but this in no way disproves that chewing responses can also occur, and may in fact be elicited by some internal hunger state. In other words, the validity of the reservoir theory of aggression does not stand or fall upon the success or failure of any experimental demonstration of either response inhibited (Adler and Hogen, 1963) or instrumental (Reynolds, Catania, and Skinner, 1963) aggression. While it is probably true that the learned-innate dichotomy suggests two mutually exclusive categories of ontogeny, there seems to be no compelling reason to assume that for any given organism, aggression may not be initiated by either one of these categories.

Once the original positions have been appropriately modified, a major source of disagreement between the respective positions can be eliminated and attention focussed upon spelling out exactly what aggressive response patterns can be classed as learned and unlearned, and to what extent such classification is applicable to different species.

In order to do this however, it is necessary to be able to differentiate a learned from an innate response. One method frequently cited (Eibl-Eibesfeldt, 1961b; Cullen, 1960) for accomplishing this is the isolation experiment. Typically this type of experiment involves removing an organism from all contact with members of its own species at or before the onset of a critical period in its development, and then determining whether a given response is subsequently performed in a manner characteristic of conspecifics not so treated. Studies employing fish (Burchard, 1961) and rats (Eibl-Eibesfeldt, 1961) suggests that the aggressive response exhibited by animals having undergone isolation occurs in the first stimulus situation normally associated with its elicitation. In addition, these same studies show that the aggressive responses are emitted in a manner typical of the species. Such evidence then would appear to warrant the modification of the original proposition to one of the forms suggested.

Is Aggression Elicited or Emitted?

The problem of determining whether aggression is elicited or emitted is similar to, but nonetheless distinct from, the learned-innate issue.

The distinction is based upon the fact that it is possible for a response to be elicited by a stimulus and still not be a learned reaction to that stimulus. Most simple reflexes, e.g., pupillary reflex, fall into this category. With this distinction, it is possible to restate the issue as follows: "All aggressive behavior in all species, is initiated by an external stimulus;" or conversely, "No aggressive behavior, in any species, is ever initiated internally."

On the face of it, it would appear that this issue is not capable of being resolved because the organism, as long as it is alive, is in constant commerce with its environment. Thus the effects of the environment upon the organism can never be totally partialled out of the interaction. Further consideration, however, suggests two possible alternatives for evaluating the effects of the environment upon aggression. The first involves specifying, in as precise a manner as possible, those stimulus conditions which are reliably effective in eliciting aggressive behavior. This of course would vary across phyletic species but once these conditions were specified, it would only remain to isolate the organism from those stimuli which are potential releasers before some critical period in its ontogeny, and then attempt to activate the aggressive response pattern by either electrical, chemical, or hormonal implants. Such a demonstration however, does not provide unequivocal evidence against the hypothesis stated above. It merely shows that it is possible to release species-typical aggression with the aid of certain activators. This limitation however, should not be taken to impugn the value of such a demonstration. In fact, current evidence seems to suggest that male sex hormones are not effective in producing

such spontaneous aggression but do seem to be effective in lowering the aggression threshold (Beeman, 1947). In addition, the literature does not appear to contain studies utilizing the isolation technique as a control procedure, and electrical and chemical stimulation of certain brain regions as a test procedure, but the studies which are available and lack the control procedure (Holst and St. Paul, 1962; Hess and Brugger, 1943; and Fisher, 1964), seem to suggest that species-typic aggression is capable of being released by such activators.

As was pointed out above, such evidence merely lends support to, but does not totally corroborate the idea that aggression can be internally activated. What remains to be shown, in order to obtain decisive evidence for the spontaneous aggression formulation, is a physiological mechanism which is selectively sensitive to deprivation states of the organism such that certain biophysical and biochemical changes occur which are antecedent to and necessary for, the maintenance of aggressive behavior. At the present time no mechanism of the kind specified has been identified. Scott (1965) apparently considers this lack of success enough evidence to discredit the spontaneous aggression hypothesis. However, the fact that such a mechanism has not yet been identified does not in itself disprove the possibility of one existing. For one thing, the search for a mechanism of this type has only been in progress for some twenty years, and for another, if psychologists had used analogous reasoning, they would have long ago given up the search for a physiological hunger mechanism.

The Fixed Action Pattern and the Spontaneous-Aggression Issue

Observational studies of the fighting behavior of a wide variety of animals (Eibl-Eibesfeldt, 1961) suggests that much fighting, particularly the initial encounters, can be classified as Fixed Action Patterns (FAPs). The significance of such classification for the spontaneous-aggression issue lies in the empirical properties of the FAP and their theoretical interpretation. Moltz (1965), in reviewing much of the ethological literature on the FAP, finds four distinguishing characteristics of this behavior pattern. These are, stereotypy of response, independence from immediate external control, spontaneity of occurrence, and independence from individual learning. By considering briefly these empirical properties it is possible to appreciate their relevance for the spontaneous-aggression controversy.

Stereotypy of response refers both to the fact that certain components of behavior designated as FAP will be executed in a highly invariant manner across species members, and within a species member over time.

Independence from immediate external control means that the behavior sequence involved in the FAP, once it is set in motion by an external stimulus, is thereafter refractory to further afferent modulation. This is to be distinguished from behavior sequences sometimes referred to as "taxes", in which both the initiation and maintenance of the response is dependent upon the continued presence of an appropriate stimulus.

Spontaneity of the FAP refers to fluctuations in the threshold of response emission resulting from privation of the appropriate stimulus. Two

empirical generalizations have been extracted from situations of this kind.

First it has been found (van Iersel, 1953; Lorenz, 1956) that the probability of occurrence of an FAP, and the intensity with which it occurs, are a positive function of the time elapsed since the response was last evoked. In addition, under such circumstances, stimuli progressively less like those normally needed for response emission will suffice to initiate the FAP (Tinbergen, 1951).

Secondly, it has been observed that when an FAP has not occurred for an extended period of time, because the stimuli needed to evoke it were absent, the FAP will go off spontaneously (van Iersel, 1953).

Finally, independence from individual learning, means that the movements involved in the FAP have not been specifically learned prior to its first occurrence. The isolation experiment (Eibl-Eibesfeldt, 1961; Cullen, 1960) and the observation of the FAP very early in ontogeny (Prechtl, 1958) suggest that the FAP is an unlearned response pattern.

These last two features of the FAP, spontaneity and independence from individual learning, together with the classification of ritualistic threat behavior as FAP, lend support to the idea that some forms of aggression may be emitted spontaneously (particularly at high levels of privation), and to the notion that certain aggressive response patterns are unlearned. A specific instance of these points is presented below under the heading, The Aggressive Display Response as a FAP.

FAP As Reward

Perhaps the most interesting empirical property of the FAP is its spontaneity of occurrence. It is of interest because of its conceptual similarity to Hullian drive. That is, both formulations posit an increase in response strength as a function of response deprivation. In addition, drive is conceptually rooted to the phenomena of reinforcement or reward. Reward is used here in its empirical sense denoting an increase in the probability of response emission following the termination of an appropriate stimulus. Although the question as to the possible reward value of stimuli which are capable of evoking FAPs has never been formally raised, there have appeared in recent years two experiments (Thompson, 1963; 1964) which address themselves to this problem. These studies, especially the first one, are of particular interest here because the FAPs in question were aggressive response patterns and because a repetition of a portion of this experiment forms the basis of the present thesis.

Choice of Subjects

In studying aggressive behavior, it is obviously helpful to investigate a species that is reliably aggressive under certain specified stimulus conditions. One such species is the Siamese Fighting Fish (Betta splendens). So aggressive are males of this species towards male conspecifics that after about three months of age, it is no longer possible to keep two males together in an unpartitioned aquarium. In addition, the Siamese Fighting Fish is an

excellent experimental subject because it will also attack, with great vigor, its own mirror image thereby making it possible to study aggression without loss or injury to subjects.

Nature of the Response

All aggression directed against conspecific males is always preceded by a characteristic ritual of display behavior. This display involves the following sequence of events. When two males are placed into an aquarium together so that they are able to see one another,¹ a remarkable series of changes occurs in each fish. As the fish approach each other, the gill (branchiostegal) membranes are projected outward at right angles to the body, forming, as it were, a brilliantly colored "shield". At the same time there is a progressive deepening of body color (which range in this species from brilliant reds, purples, blues, lavenders, greens, and whites, to iridescent forms of these same colors) extending to the dorsal, ventral, and caudal fins, which by this time are widely spread and firmly erect. The display response is followed by a "sparring" position which both fish assume to preface actual combat. This involves a zig-zag swimming motion toward each other with both fish eventually

¹ In a preliminary experiment, the author removed extensive portions of the eyes of a mature male so that only the fish's ability to detect changes in light intensity remained intact. When a visually intact male was placed in an unpartitioned aquarium with the blinded male, the intact, but not the blinded male, exhibited the display response. While this experiment does not provide conclusive evidence, it does suggest that the display response is dependent upon a functionally efficient visual system.

positioned side by side, pointed in the same direction. This position is usually held for a few seconds, in which time both fish exhibit an apparently tense, stiff-bodied, jerky "body-wag" which probably represents the final threat encounter before actual combat. A photograph of a male Siamese Fighting Fish in the threat display position before a mirror is shown in Fig. 1. Physical combat commences with the termination of display behavior. In general, the most common points of attack are the anal, caudal, and ventral fins although sometimes the sides of the body and gill membranes are attacked. At some point in the actual fighting, one or both fish will surface for air.² This phase signals a "time out" from fighting in which all attacks are suspended until both fish have returned to their respective combat positions. In well matched fish, fighting may last for several hours. The winner is usually decided not so much by the amount or extent of any apparent physical injury, but by the state of exhaustion of one of the combatants. Thus a well torn fish may prepare for another encounter while his less battered opponent may apparently be unwilling to engage in further combat.³

² Siamese Fighting Fish, like other anabantid species are not able to extract sufficient quantities of dissolved oxygen from the water in amounts necessary to sustain normal activity. Consequently, they are equipped with a labyrinth mechanism located above the gills which, being endowed with a rich supply of blood, acts much like a lung to provide the organism with oxygen in amounts necessary for survival.

³ Observation of male Siamese Fighting Fish in situations in which these Ss have access to their mirror image provides a tentative explanation of this phenomenon. I have observed that after about a week of repeated exposure to their mirror image, Siamese Fighting Fish will begin to lose portions of their caudal and ventral fins. These deletions appear to be quite similar to those resulting from physical combat. It is suggested here that this fin loss serves as a protective

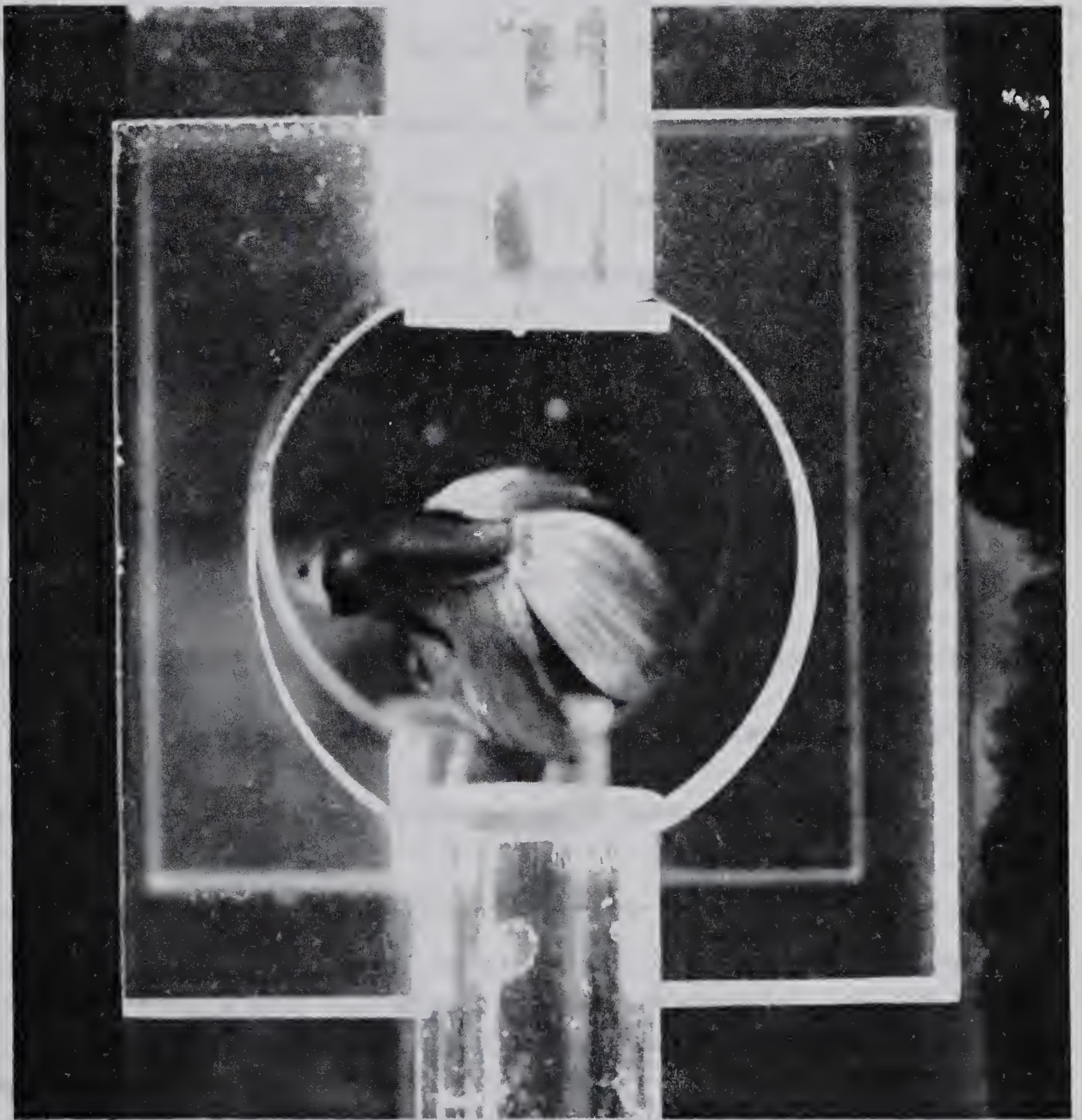


Fig. 1. Photograph of male Siamese Fighting Fish displaying to his mirror image.

The Aggressive Display Response as a FAP

Having considered the nature of the aggressive display response and having also reviewed the empirical properties of the FAP, it is now worthwhile to examine whether the display response can be classified as a FAP. Before attempting to do this however, it should be pointed out that there is as yet nothing like a general consensus of opinion among ethologists or instinct theorists as to the necessary and sufficient properties that a response pattern must exhibit before it can be included into the class of FAPs. Sackett (1963) has attempted to bypass the problem of class inclusion by expanding the ethological conception of the FAP to include behavior sequences of the type ${}_sU_r$. That is, any unconditioned response which is reliably elicited by an unconditioned stimulus is considered a FAP. This policy, however lucrative it may appear, does not resolve the critical issue of independence from individual learning because it still remains to be shown that the ${}_sU_r$ in question is indeed a nonlearned response and the problems involved in doing this are precisely those encountered in determining whether a so-called instinctive act is learned or innate.

device for fish in combat situations. Specifically it is argued that the structural composition of the fin is such that when a minimum of pressure is applied to a portion of the fin, that portion is easily dislodged from the remainder of the structure so that the resulting injury is only apparent and not real. The advantage of such a mechanism in terms of survival value, especially for such an aggressive species is apparent, and interestingly, is known to occur in other species (e.g. certain lizards). With regard to the original problem, this speculation suggests a reason why the extent of apparent physical injury may not be a valid indication of the combative status of a participant.

In addition, the problem is further confounded by the fact that there are virtually no reported experimental studies of the behavior of the Siamese Fighting Fish in test situations relevant to the four empirical properties of the FAP. However, in spite of the paucity of experimental studies, and in spite of the lack of agreement with regard to criteria for class inclusion, it is still possible to make a temporary classification of the display response as FAP. The basis for such classification is twofold; the first line of argument coming from ad hoc experimental studies conducted by the author, and the second, from experimental studies of species exhibiting similar display behavior.

With regard to the first line of argument, the author has been able to elicit both gill extension and the erection of the fins with the use of a lighted match in adult males kept in isolation from conspecifics. More dramatically, I have been able to trigger the entire sequence of aggressive behavior in a fish kept in a community aquarium by the introduction of a clear plastic bag containing fish of unrelated species. This demonstration is important for two reasons. First, Siamese Fighting Fish do not employ the aggressive display response against non-species members. Secondly, once the initial gill extension began (apparently in response to the fish in the bag) the entire sequence of events described in the fighting ritual was executed faithfully. The actual attack response, which was also present, was directed neither towards the fish in the aquarium nor the fish in the bag. In short, the fish appeared to be displaying to, and directing attacks against, the surrounding water. Both these demonstrations then suggest that the display response sequence incorporates the FAP properties of spontaneity and independence from immediate

external control.

The second line of evidence comes from isolation studies of fish which exhibit threat display behavior similar to that of the Siamese Fighting Fish. Studies by Burchard (1961), and Baerends and Baerends (1950) employing cichlid fish suggests that the display response is not learned from conspecifics or through exercise of the component elements. While similar isolation studies remain to be carried out with Siamese Fighting Fish, it is probably safe to classify, at least tentatively, the display response of this species as a FAP.

The Thompson Experiment

In 1963, Travis Thompson attempted to show that the stimuli which appear to evoke unlearned aggressive behavior in male Siamese Fighting Fish could act as a positive reinforcer for certain instrumental responses. He reasoned that if aggression (or more accurately, the stimuli which evoke aggression) had reinforcing properties, it would be possible to increase the probability of occurrence of some "neutral" response which was instrumental in bringing the subject (S), to an aggressive reward. In order to test this assumption experimentally, Thompson trained each of four Ss to swim through a clear plastic ring, 3 in. in diameter, for which they were rewarded by the presentation of their mirror image. Reward presentation was accomplished when S swam through the ring interrupting a beam of light projected from a photo-cell system. Upon the interruption of the light beam, a 75-w. light-bulb located behind a two-way glass, was switched from an "on" to an "off" position, thereby making the glass

a mirror. Mirror presentation (reward) lasted 20 sec. at the end of which time the light bulb switched to the "on" position, converting the mirror to glass. An apparatus similar to the one used by Thompson is shown on the right hand side of the photograph on page 43.

Using this procedure, Thompson was able to demonstrate that the presentation of stimuli which normally evoke aggressive behavior in Siamese Fighting Fish could initiate and sustain new behavior, while the termination of such stimuli acted to eliminate these acquired responses. Figure 2, taken from Thompson's data, shows the course of acquisition and extinction of the ring swimming response. The dependent variable, the number of responses, is plotted on the ordinate, while the independent variable, 24-hr. sessions, is plotted on the abscissa. In addition to this portion of the experiment, Thompson also tested these same Ss under two other conditions of reward. These conditions however, are not crucial to the present thesis and need not be considered here.

Criticism of the Thompson Experiment

Inspection of Fig. 2 indicates the presence of an operant control period. That is, during the first two days of experimentation prior to reward presentation, Ss were maintained in the test apparatus and the number of non-reinforced (operant) responses recorded. Such a control procedure is necessary because it provides a baseline against which the supposed conditioning phase can be evaluated. Relatively high operant rates in proportion to so-called conditioning rates leaves little justification for the conclusion that the treatment condition resulted in conditioning of the response in question. Alternatively,

THOMPSON DATA

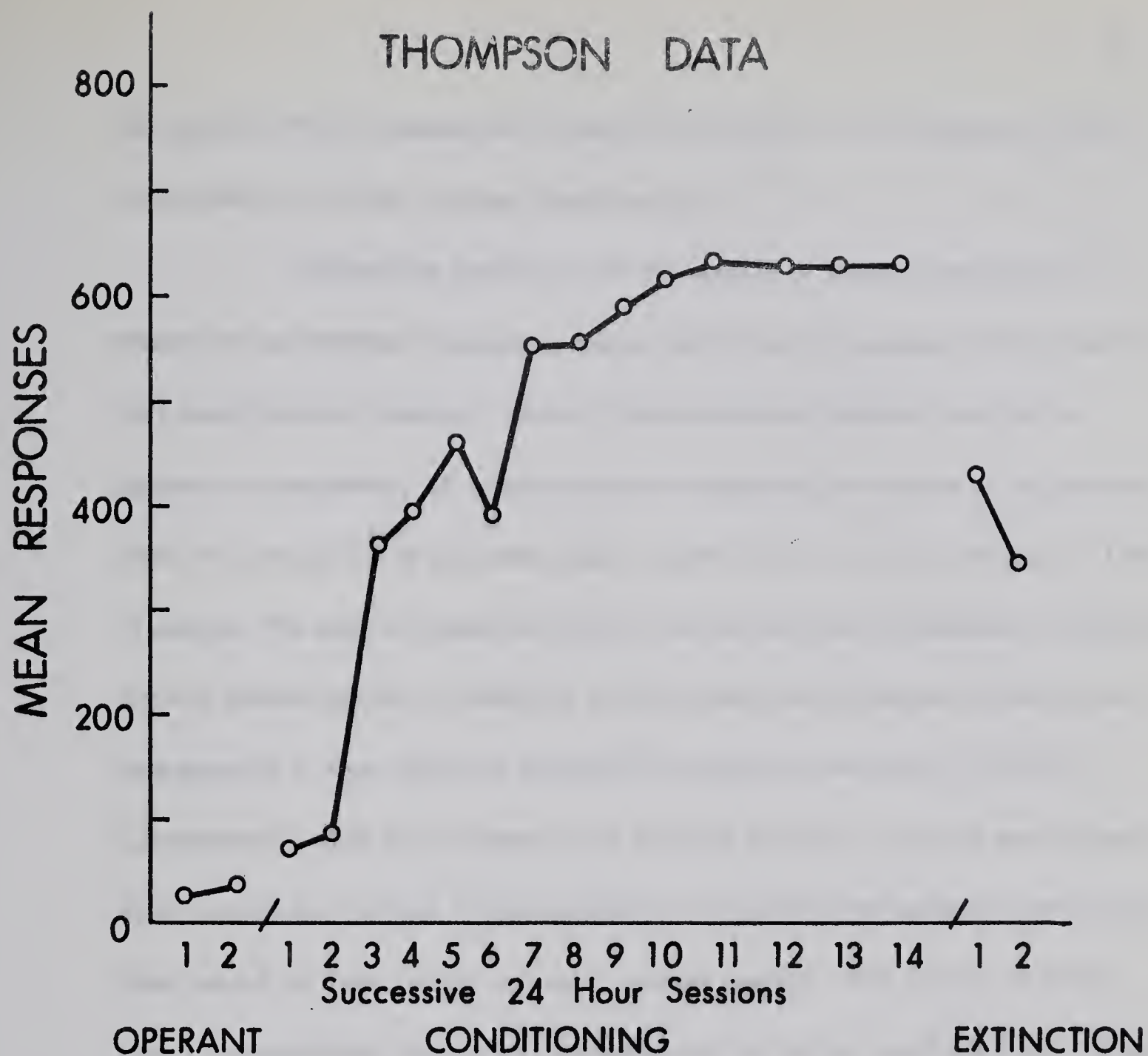


Fig. 2. Data adapted from Thompson's study showing the acquisition and extinction of the ring-swimming response. Data show mean daily performance.

low operant rates in proportion to conditioning rates, in the absence of other confounding variables, suggest conditioning.

Subjective evaluation of the number of operant responses in proportion to treatment responses, indicated in Fig. 2, suggests that Ss were in fact conditioned. However, since in this experiment reward involved an aggressive component, other considerations regarding the nature of aggression affect the tenability of this conclusion. Specifically, mirror presentation (and of course, the normal encounter with a rival male) tends to produce a heightened state of arousal which, in addition to those behavioral changes already noted (see page 16), also results in an overall increase in the level of activity. Consequently, with an increase in the level of activity, it would seem reasonable to posit an increase in the probability of response emission over and above what would be expected for a normal operant session. The extent to which this is true provides, as it were, a measure of the actual conditioning. Inherent in these considerations then, is the contention that the extent of conditioning (y), is a joint function of the reward value of the stimulus (w), and the overall level of activity (x). That is, $y = f(w, x)$. Therefore by controlling for x , the level of activity, a better estimate of the effectiveness of w , the reward procedure, can be obtained.

In addition to the problem of level of activity, another problem, the precise nature of the reward, also arises. Here the objection can be raised that it was not the aggression supposedly released by the particular afferent inflow generated by the presence of a rival male which was rewarding, but

merely the afferent stimulation as such, and nothing more. Butler (1957) for example has shown that monkeys kept in relative isolation from conspecifics will learn certain instrumental responses to secure visual contact with conspecifics. However, the alternative explanations of conditioning mediated by social reinforcers as Butler's work suggests, or other explanations such as novelty-seeking offered by Fiske and Maddi (1963), can be dealt with on both logical and experimental grounds.

Logically it can be argued that if it were just the sight of another Siamese Fighting Fish (and not the aggressive component) which was reinforcing, one would not expect the fish to exhibit the display response. Since the display response is intimately associated with aggression and since the display response occurs virtually every time S swims through the ring, it is reasonable to assume that an aggressive component is involved in the maintenance of the conditioned response.

Experimentally, if it is simply the afferent inflow impinging upon the retina which is somehow reinforcing, it should be possible to condition the ring-swimming response when any form of afferent stimulation is used as reward.

CHAPTER THREE

Two experiments are described in the pages that follow. A second experiment was necessitated by unexpected results obtained in the first portion of the first experiment.

The First Experiment

Experiment I, originally intended as the major experimental contribution of the present thesis, had a two-fold purpose. First, with the use of a modified procedure, it was an attempt to replicate the Thompson demonstration, and secondly it was an attempt to take into account those problems raised by the demonstration.

Subjects

The Ss were 12 adult male Siamese Fighting Fish purchased from a local breeder. The Ss, all littermates, were approximately 8 mo. of age at the time of testing. All Ss were maintained on a commercial food preparation, "Tetra-Min", and on live White Worms (Enchytraeus albinus). Feeding occurred once daily approximately 3 hr. prior to testing.

Apparatus

All Ss were housed in a 17-gal. plexiglas aquarium, 32" x 12" x 10". The aquarium was partitioned into 12 compartments, each with a water

capacity of about 1 1/2-gal., by the incorporation of 11 black plexiglass baffles. Each baffle contained four randomly placed openings, 1/16" in diameter, to insure relatively homogeneous water conditions throughout the aquarium. The aquarium water was cleaned and circulated by an outside filter and a vibrator-type air pump.

The test aquarium was a standard stainless steel 2 1/2-gal. aquarium, 12" x 6" x 8". Two plastic strips, 1/2" x 3/4" x 8", each containing 2 sunken channels the length of the strip, were inserted opposite each other on each side of the aquarium. A mirror, 5 1/2" x 7 1/2", was inserted between one set of channels, and a white plastic shield, 5 1/2" x 7 1/2", inserted into the remaining channel in front of the mirror. A string was tied to the top of the shield and incorporated into a pulley system located above the aquarium. This arrangement made it possible to mechanically raise and lower the shield. Suspended into the aquarium on a brass rod attached to the pulley system was a clear plastic ring with an inside diameter of 3". A photograph of this apparatus is shown in Fig. 3.

Procedure

The procedural steps outlined immediately below represent common experimental treatment for all conditions. Group specific procedures appear directly after this section.

In order to effect a smooth transfer from the home aquarium to the test chamber, each S was caught in a net and allowed to swim free in the

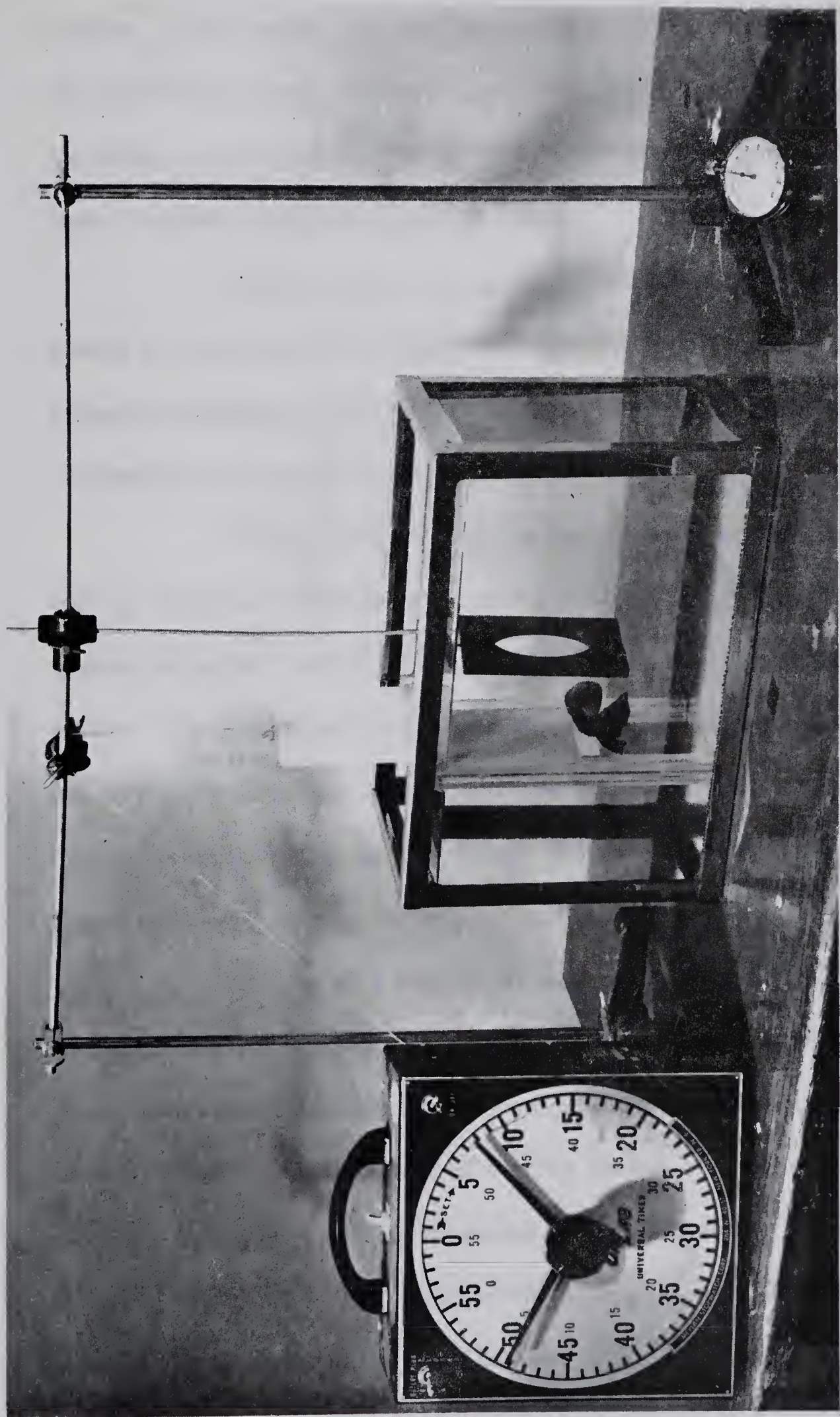


Fig. 3. Photograph of Apparatus Used in Experiment I. A Siamese Fighting Fish is Shown Displaying Toward His Mirror Image.

test chamber. On any given day, the total time spent in the test chamber was 20-min. At the end of this time S was returned to the home aquarium. When all Ss had been tested, the test aquarium was emptied and replaced with clean tap water. It was necessary to treat the tap water with a commercial dechlorinator in order to make the water habitable.

Two days prior to the operant phase of the experiment, S was placed in the test aquarium, which was devoid of all test equipment, and allowed to explore for 20 min. The purpose of this was to familiarize S with the handling routine and the new environment.

On days three and four an operant level was determined for each S. Prior to the determination of the operant level, S was given a 5-min. adaptation period in which all the test equipment was present except the ring device. The submersion of the ring device signalled the end of the adaptation period and the beginning of the operant period. In this phase the number of non-reinforced responses were recorded. A response was recorded whenever S passed completely through the ring.

Each day of the conditioning phase was marked by a 5-min. adaptation period followed immediately by a 15-min. conditioning period. As with the operant schedule, the initiation of the conditioning period was always marked by the submersion of the ring device. Whenever a response was made during the conditioning period the shield covering the mirror was mechanically raised by gently but swiftly pulling the string attached to the shield. Reward presentation lasted 20 sec. at the end of which time the shield

was lowered. With the termination of the 15-min. conditioning period, S was returned to the home aquarium.

Finally in an attempt to reduce systematic biasing effects, all Ss were numbered and randomly assigned to groups. Groups I and II were run together prior to groups III and IV. Six Ss were assigned to each group and on each day of testing, the order in which Ss were run was randomized.

Specific Procedural Considerations

Table I outlines the experimental procedure for each treatment condition. In treatment condition I the reward used was S's mirror image. Reward presentation was contingent upon successful completion of the ring-swimming response. That is, whenever S swam completely through the ring, the shield covering the mirror was raised and S allowed to see his mirror image for 20 sec. In order to establish the ring-swimming response however, it was necessary to employ a "shaping" technique. This involves rewarding those responses which successively approach the desired response. As in the Thompson experiment, extinction began when Ss reached a stable level of performance.

During treatment condition II, the reward employed was the S's mirror image, but reward presentation was not response contingent. That is, S was not consistently rewarded for successful completion of the ring-swimming response or any other specific response sequence. Instead, the pattern of reward presentation was determined by randomly generated time intervals such that the inter-trial interval was not less than 1 sec. or greater than 60 sec.

Table I
Summary of Experimental Procedure

| TREATMENT CONDITIONS | REWARD USED | REWARD AVAILABILITY | N |
|-------------------------|----------------------------------|---------------------|---|
| I | mirror image | response contingent | 6 |
| II | mirror image | random-temporal | 6 |
| III | male Swordtail | response contingent | - |
| IV | Blinded Siamese Fighting Fish | response contingent | - |

Ring-swimming responses were recorded during "time out" from reinforcement. The purpose of this procedure was to control for the predicted increment in activity generated by the presentation of the UCS.

In treatment condition III, the reward stimulus used was a live male Swordtail (Xiphophorus helleri), and the acquisition of reward by S was response contingent. In order to house the Swordtail in the test chamber, and at the same time regulate reward presentation, the mirror located behind the shield was replaced with a clear plastic sheet. With this arrangement, the Swordtail could swim freely in the portion of the aquarium separating him from S and at the same time be visible to S. The purpose of this treatment was to determine whether the afferent stimulation of any fish could suffice to produce conditioning.

Finally in phase IV, a live but blinded male Siamese Fighting Fish was used for the reward condition and the acquisition of reward by S was again response contingent. The blinded male was separated from S by the arrangement described in treatment condition III for the containment of the Swordtail. The purpose of this procedure was to try to separate out, as far as possible, the visual image of a Siamese Fighting Fish as reinforcer, from the visual image of a Siamese Fighting Fish in the threat display position as reinforcer. This was made possible by the fact that the blinded male was unable to see his rival and hence would not display.

Results

After completing the first two phase conditions, it became apparent that it would not be meaningful to proceed to treatment conditions III and IV and that another experiment more in accord with the original Thompson experiment would have to be conducted. More extensive discussion of these points appears in the discussion section below.

Figure 4 shows the number of responses summed over Ss in groups I and II for each day of the operant and conditioning periods. During the operant period, the number of responses recorded for the control group was greater than the number obtained by the experimental group. Actually as Fig. 4 shows, no responses were recorded during this period for the experimental group. Presumably, the difference in operant rates between groups could be attributed to fortuitous assignment to groups since these differences appeared to occur in the absence of any detectable treatment condition. To substantiate this, a product moment correlation coefficient was computed to test the hypothesis that operant rate was independent of conditioning rate (i.e. that the correlation between these two variables was zero). An r of .24 was obtained which although positive was found not to differ significantly from zero correlation ($t = 0.77$, $\alpha = .05$, 10 df). It was therefore concluded that the difference in operant output between groups was not a significant factor in determining response output during conditioning.

In addition, it should also be observed that by the second day of conditioning both groups have matched each other on response output and

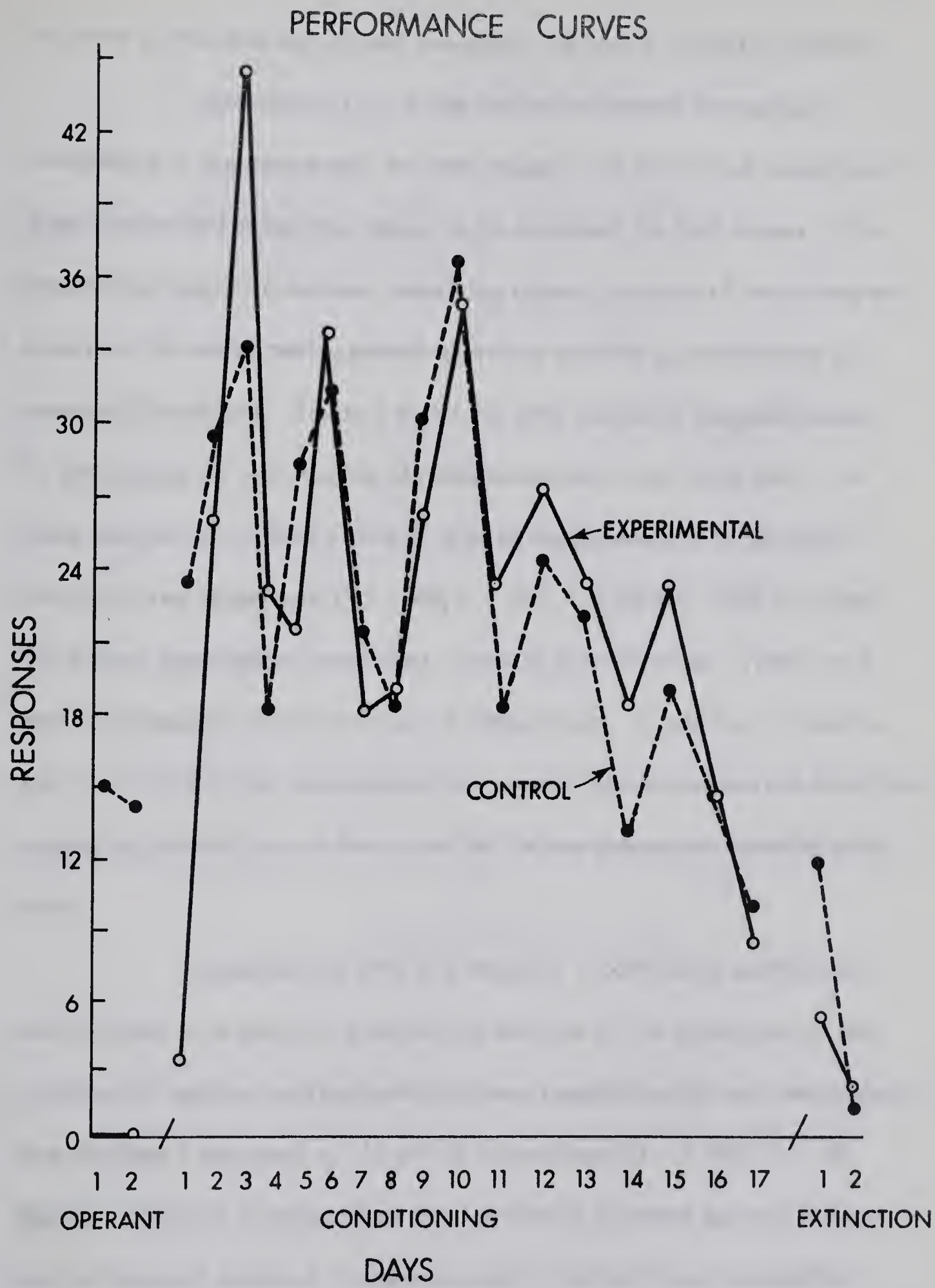


Fig. 4. Performance of experimental (reward, response contingent) and control (reward, not response contingent) groups.

this state of affairs is maintained throughout the entire 17 days of training.

Inspection of Fig. 4 also indicates frequent day-to-day fluctuations in response output for both groups. The extent and direction of these fluctuations moreover, appear to be consistent for both groups. This observation suggests a common underlying cause. Analysis of water temperatures over the entire testing period appears to provide an explanation of response fluctuations. Figure 5 shows the total number of responses made by both groups for each degree of temperature occurring in the study. A trend analysis of this data (Table 2) showed the presence of a significant over-all linear component ($F = 6.40, \alpha = .05, 1 \text{ \& } 50 \text{ df}$). That is, under the present experimental conditions, response output varies, in part, as a positive-sloped monotonic function of temperature. In addition, it can be seen from Table 2 that the temperature \times reward interaction was not significant, suggesting that the form of the curves for the two groups was essentially the same.

In conjunction with this analysis, a correlation coefficient, which allows us to obtain a quantitative estimate of the importance of one variable for another, was computed between response output and temperature. The obtained r was equal to .18 which is significant ($t = 2.358, \alpha = .05, 166 \text{ df}$). While it is evident that this correlation accounts for only 3.2 per cent of the total variance in response output, the significant correlation together with the significant linear trend suggests that temperature was a determining factor of response fluctuation.

TEMPERATURE - RESPONSE OUTPUT RELATIONSHIP

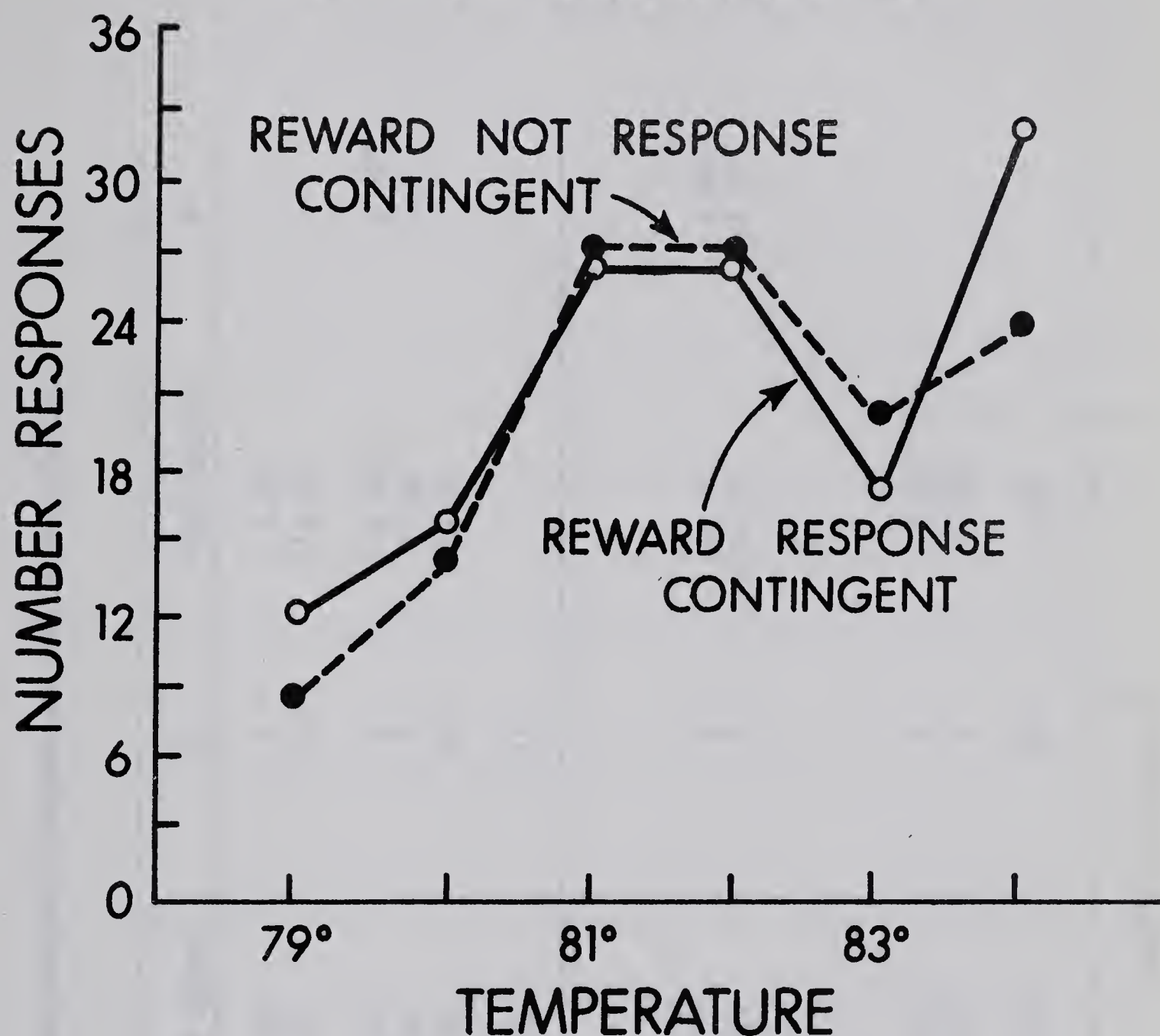


Fig. 5. Graph showing how response output varies as a function of temperature. A trend analysis of this data indicated: (1) significant linear components, and (2) no significant difference in overall trend between groups.

Table 2. Trend Analysis of Temperature and Response Output

| Source of Variation | Sum of Squares | df | Mean Square | F |
|----------------------------------|----------------|----|-------------|--------|
| A: Reward | 0.55 | 1 | 0.55 | - |
| Error (a) | 1109.47 | 10 | 110.95 | - |
| B: Temperature | 94.61 | 5 | 18.92 | 2.52* |
| A x B | 7.87 | 5 | 1.57 | 0.21 |
| error (b) | 375.35 | 50 | 7.51 | |
| Total | 1587.85 | 71 | | |
| ----- | | | | |
| Over-all Trend | | | | |
| linear component | 48.10 | 1 | 48.10 | 6.40** |
| quadratic component | 14.05 | 1 | 14.05 | 1.87 |
| Reward x Temperature Interaction | | | | |
| linear component | 0.03 | 1 | 0.03 | - |
| quadratic component | 5.69 | 1 | 5.69 | - |
| error (b) | 375.35 | 50 | 7.51 | |

* Significant Beyond .05

** Significant Beyond .01

Finally, response peaks appear on the third, sixth, and tenth day of training and from this point on, response output drops continuously until day 17 when testing was discontinued.

Discussion

Two related factors were responsible for the decision to discontinue training. These were the progressive decrease in the absolute number of responses exhibited by both groups, and a marked tendency for most Ss to cease responding to the UCS. These two conditions, together with the fact that no apparent difference existed in response rate between groups strongly suggested that conditioning had not occurred. Therefore, the apparent increase in response rate during the early stages of conditioning over the initial operant rate is attributed to the excitatory effect of the UCS. Moreover, the progressive decrease in response rate during the latter stages of training is assumed to result from the phenomena of adaptation resulting from repeated exposure to the UCS.

The question now arises as to why Thompson was able to obtain conditioning while the effect was not repeatable in the present study. One obvious answer immediately presents itself. In the Thompson study, S was maintained in the test chamber throughout the duration of the study. That is, 24 hr. a day for 17 days, S had access to the response manipulandum. It is reasonable to assume then that the constant availability of the response manipulandum provided Thompson's Ss with a greater opportunity to learn the

response in question. Thus if according to Fig. 2 we conservatively estimate that Thompson's Ss learned the response by the third day of training, then mathematically it took on the average, a total of 72 hr. for conditioning to occur. If this figure were translated into the present procedure, it would have required approximately 288 days of training to establish conditioning. In view of this it would appear that a 15 min. daily training procedure is not sufficient to produce conditioning of the ring swimming response in a pragmatically feasible length of time. Alternatively, the well-established superiority of distributed over massed practice (Lorge, 1930; Kimble & Bilodeau, 1949) suggests that other factors may have been operative to effect negative results. Presumably an optimal daily training period does exist in which conditioning of this response is obtainable, but this information will have to wait for a parametric study.

It was implied in the comment on the superiority of distributed over massed practice that 15 min. might be adequate to produce conditioning if other factors, supposedly detrimental to conditioning, were not operative. Casual observation of Ss during training suggests that emotionality may have been one of these factors. Specifically, increases in emotionality above normal levels could have occurred as a result of the procedural manipulations involved in transporting S, and in the policy of shield raising.

It was pointed out earlier that in bringing S from the home aquarium to the test chamber, it was necessary to chase and then catch S in a net. Despite some skill in catching fish, and despite the pretraining period,

the author frequently encountered difficulty in netting Ss, with some chases lasting several minutes. Therefore, it is suggested that the experience of being chased, netted, and temporarily removed from water, adversely affected subsequent performance. The 5 min. adaptation period and the two-day pretraining period were incorporated, of course, to minimize such effects.

A second source of emotionality may have been induced by the policy of suddenly raising the shield whenever S recorded a response. At such times, S exhibited withdrawal behavior--such as backing off and hastily swimming away from the test area--and thereafter appeared reluctant to approach the ring or shield. Rapid shield raising was necessary, however, to minimize as much as possible the time interval between the response and reward presentation. This procedure was necessitated by the fact that even short delays of reinforcement can adversely affect response acquisition (Perin, 1945; Logan, 1952).

These two factors, time availability for conditioning, and emotionality presumably produced by the netting and shield raising policies, appear to explain the discrepancy in experimental results. However, in view of the facts regarding the utilization, in this study, of distributed instead of massed practice, and a control group apparently effective in accounting for response output, it became essential to ask whether this same control group would not be equally effective in accounting for the results obtained in a more exact repetition of the Thompson demonstration.

Experiment II

Except for one or two minor changes in test equipment, and except for the incorporation in the present study of a yoked control group and an operant control group, the following experiment follows very closely the main portion of the Thompson experiment. Therefore, except where otherwise indicated, the steps outlined below in Experiment II are those which appeared in the original Thompson demonstration.

Before considering the details of Experiment II, it is probably worthwhile at this point to examine the logic of the control groups used in this study. In Experiment I, an attempt was made to take into account the excitatory effect of the UCS by randomly presenting reinforcements to members of the control group. In so doing however, differences between groups occurred on two important variables. These were the number, and temporal distribution of reward presentations. Although these variables are not of particular experimental interest here, their uncontrolled variation presents problems because it is possible to attribute differences between groups to the differential effects of these variables. The yoked control design is typically employed to minimize such confounding. The advantage of employing this design is that it allows the experimenter to obtain the excitatory effect of the UCS, and at the same time, to exercise greater control of the experimental contingencies by equating the number and temporal distribution of reinforcements between groups.

The point of the operant control group is simply that it provides a reward-free baseline against which various reward contingencies can be evaluated.

Subjects

The Ss were 12, 7-mo. old male Siamese Fighting Fish, purchased from a local breeder. The Ss were fed on a mixed diet of live and powdered foods.

Apparatus

The housing unit employed in Experiment I was used again in this experiment.

The test equipment consisted of two stainless steel aquariums, 12" x 6" x 8"; two 4" plexiglass squares each containing a circular opening 3" in diameter and fitted with two pieces of 1" diameter plastic tubing; two sheets of two-way mirror, 4" x 8"; two 100-w. frosted light bulbs; a triple channel event recorder (Davis Scientific Company); two photo-cell systems; two Hunter timers; two aquarium thermometers; and two 8" high wooden stands.

Each aquarium was mounted on a wooden stand and fitted with a photo-cell system such that the receiving portion of the system was situated below the aquarium and underneath the stand, while the light source or sending portion of the system was mounted on a plywood sheet above the aquarium. Unobstructed passage of light was made possible by the placement of a 3/8" hole in the stand and a 1" hole in the plywood sheet above the aquarium. Each plexiglass ring-device was placed into a separate aquarium so that the tubing portion of this device lay in the vertical plane of light emitted by the photo-cell

system. Fastened to the outside of each aquarium, and located 3" directly behind the ring device, was a two-way mirror. Finally, each photo-cell system was wired to both Hunter timers and to two specified channels of the event recorder. A photograph of this equipment is shown in Fig. 6.

For purposes of simplicity in describing the functional operation of the equipment, one aquarium, the test aquarium, will be designated AA, while the other aquarium, the yoke control aquarium, will be designated AB.

During the operant phase of the experiment, the interruption by S of the light beam projected from the photo-cell system in either aquarium resulted in no apparent change of S's physical environment, but the event itself was recorded on separate channels of the event recorder.

During the conditioning phase of the experiment, the interruption by S of the light beam projected from the photo-cell system in aquarium AA caused the light bulbs located behind each aquarium to switch from normally on, to an off position. The resulting change in the differential intensity of light impinging upon each two-way mirror acted to convert the non-reflecting mirror (light bulb normally on) to a normal reflecting mirror (light bulb off). The occurrence of this event was simultaneously recorded on the channel of the event recorder specified for S in AA. Mirror presentation, which was controlled by the Hunter timers, lasted 20 sec. during which time further ring swimming responses by either S were not recorded. The sequence of events involved in the acquisition of a mirror presentation is shown in the photograph of Fig. 7.

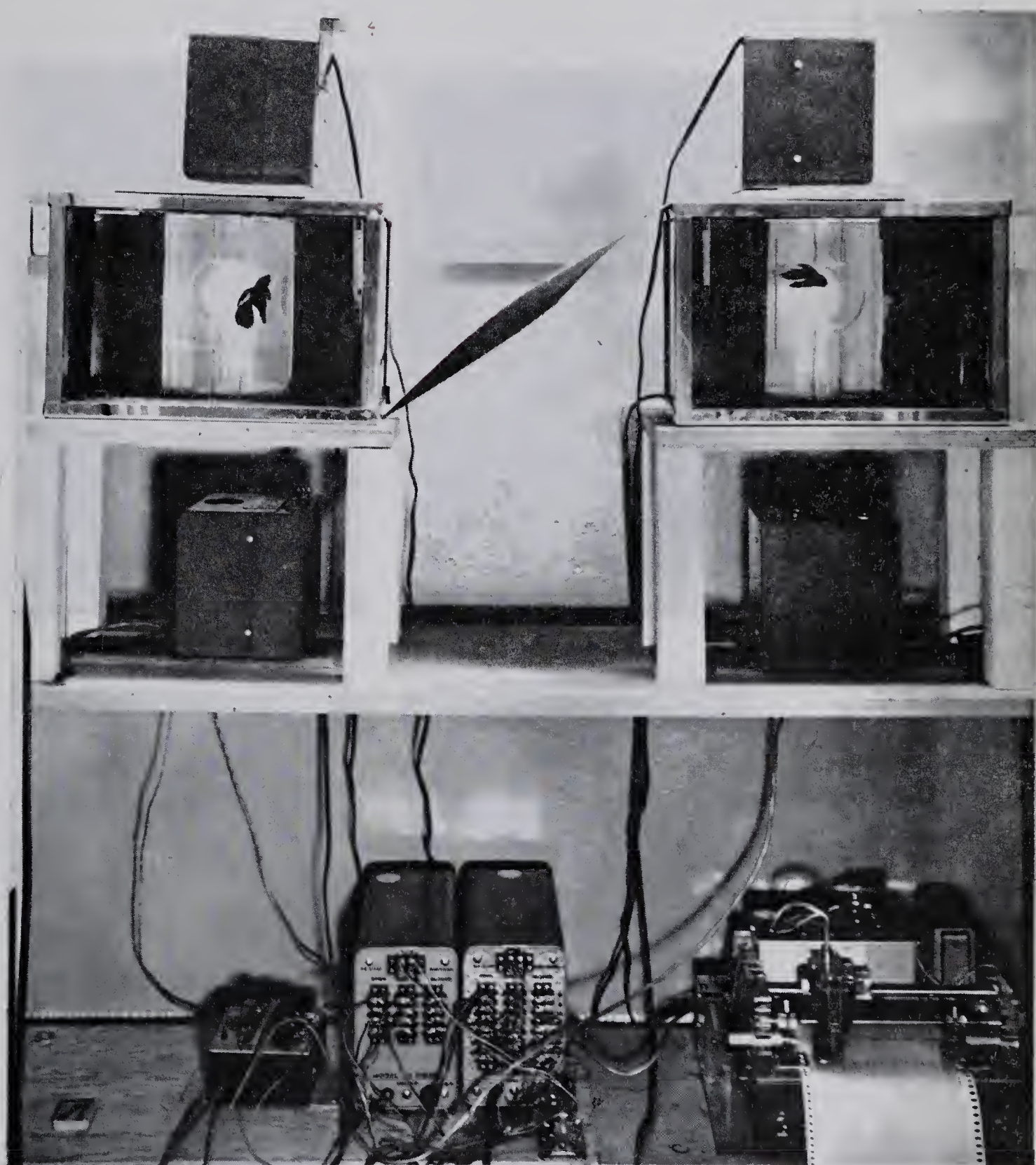


Fig. 6. Photograph of Apparatus Used in Experiment II. The Aquarium Shown on the Right Side of the Photograph Operated much like the One Used in the Thompson Experiment.

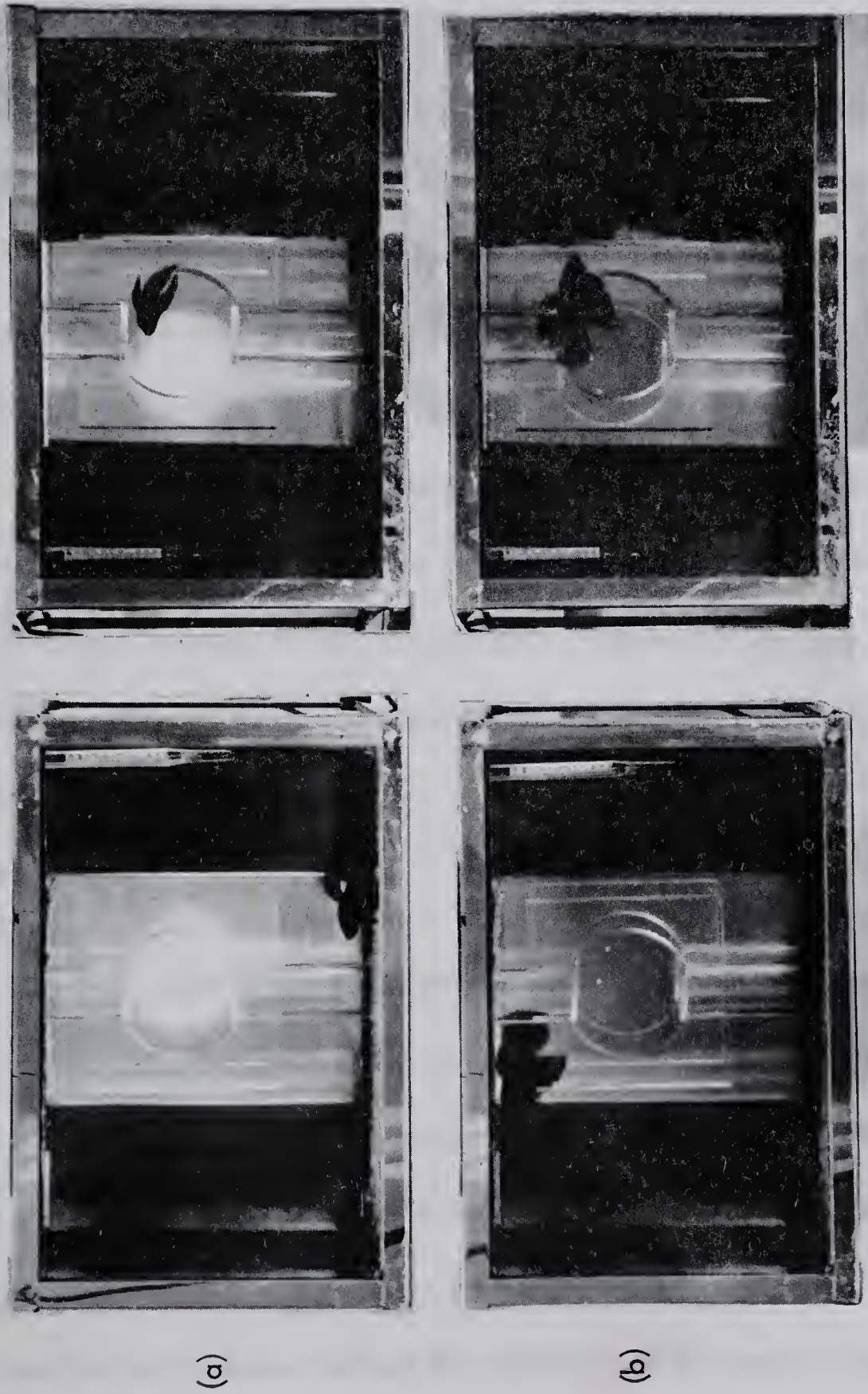


Fig. 7. Sequence of Events Involved in the Acquisition of Mirror Presentation (Reward) in the Yoked-Control Design. The S in the Aquarium on the Right Controls the Number and Temporal Distribution of Reinforcements. Sequence (a) Shows This S About to Make a Response. In (b) both S_s are Displaying to Their Mirror Image.

With the termination of the 20-sec. mirror presentation period, the light bulbs located behind each aquarium switched back to the on position producing once again, a non-reflecting mirror (glass). One second after this conversion had occurred, S in AA could, by making another response, once again initiate the entire sequence of events involved in mirror presentation.

During the extinction phase of the experiment, the Hunter timers were rewired so as to provide for functional operation of the equipment identical to the performance described in the operant stage.

Finally, the equipment was so programmed that regardless of the experimental phase, any response recorded by S in AB was ineffective in changing the light intensity of either aquarium. Responses made by S in AB were, however, recorded on a separate channel of the event recorder.

Procedure

Eight Ss were randomly assigned to the experimental and yoke control groups so that each group contained four Ss. On the first day of testing one S from each group was randomly selected and placed into the appropriate test chamber. All Ss remained in the test chambers 24 hr. a day each day for the duration of the experiment, which lasted 14 days. The introduction of Ss into the test chambers marked the beginning of the operant phase. During the course of this two-day operant period responses made by either S were not reinforced though these responses were recorded on the respective channels of

the event recorder.

Approximately 48 hr. after the beginning of the operant phase, the Hunter timers were rewired to accommodate the conditioning program. During this phase, whenever S in AA recorded a response, both Ss would receive mirror presentation (reward) for an interval of 20 sec. At the same time, a response was recorded for S in AA but not for S in AB. During reinforcement neither S recorded responses while during "time out" from reinforcement S in AB could record responses. The conditioning phase lasted a total of 10 days at the end of which the timers were again rewired to accommodate an extinction program.

During extinction, responses made by either S did not result in reinforcement. This phase, which represented the final stage of the experimental treatment, lasted two days at the end of which time Ss were discarded, the equipment cleaned, and a new pair of Ss placed into the test chambers for the next repetition of the experiment.

An Operant Control Group

While these Ss were being tested, it became apparent that any conclusions regarding the reward value of the stimulus event in question would necessarily be qualified by the omission of an operant control group. That is, the argument could be advanced that a propensity for ring swimming increases simply as a function of time spent in the test chamber.

To control for this eventuality, each of four Ss were placed into separate aquaria containing apparatus similar in function to that described for the yoked control group. Visual reinforcement of the kind described never occurred for Ss in this group. While ring swimming did not effect a change in S's environment, such responses were recorded on separate event counters. A photograph of this equipment is shown in Appendix E.

Results

Figure 8 shows the operant, acquisition and extinction phases of training for the operant control, yoke control, and experimental groups. It can be seen that during the operant phase of the experiment, there are no apparent differences in response output between groups ($t = 0.514$, $\alpha = .05$, 14 df, for the experimental vs. yoked comparison). This suggests that a differential propensity for ring swimming does not exist in the sample of Ss chosen for study.

On the other hand, the effectiveness of the UCS in eliciting ring swimming is shown in the conditioning phase of the experiment. Where reward presentation is response contingent, the total response output on any given day is significantly greater than when reward is not determined by the response ($t = 11.09$, $\alpha = .01$, 78 df).

It can also be seen that when reward presentation is independent of the response, response output is greater than when a reward factor is eliminated entirely. This difference is significant ($t = 3.96$, $\alpha = .01$, 38 df).

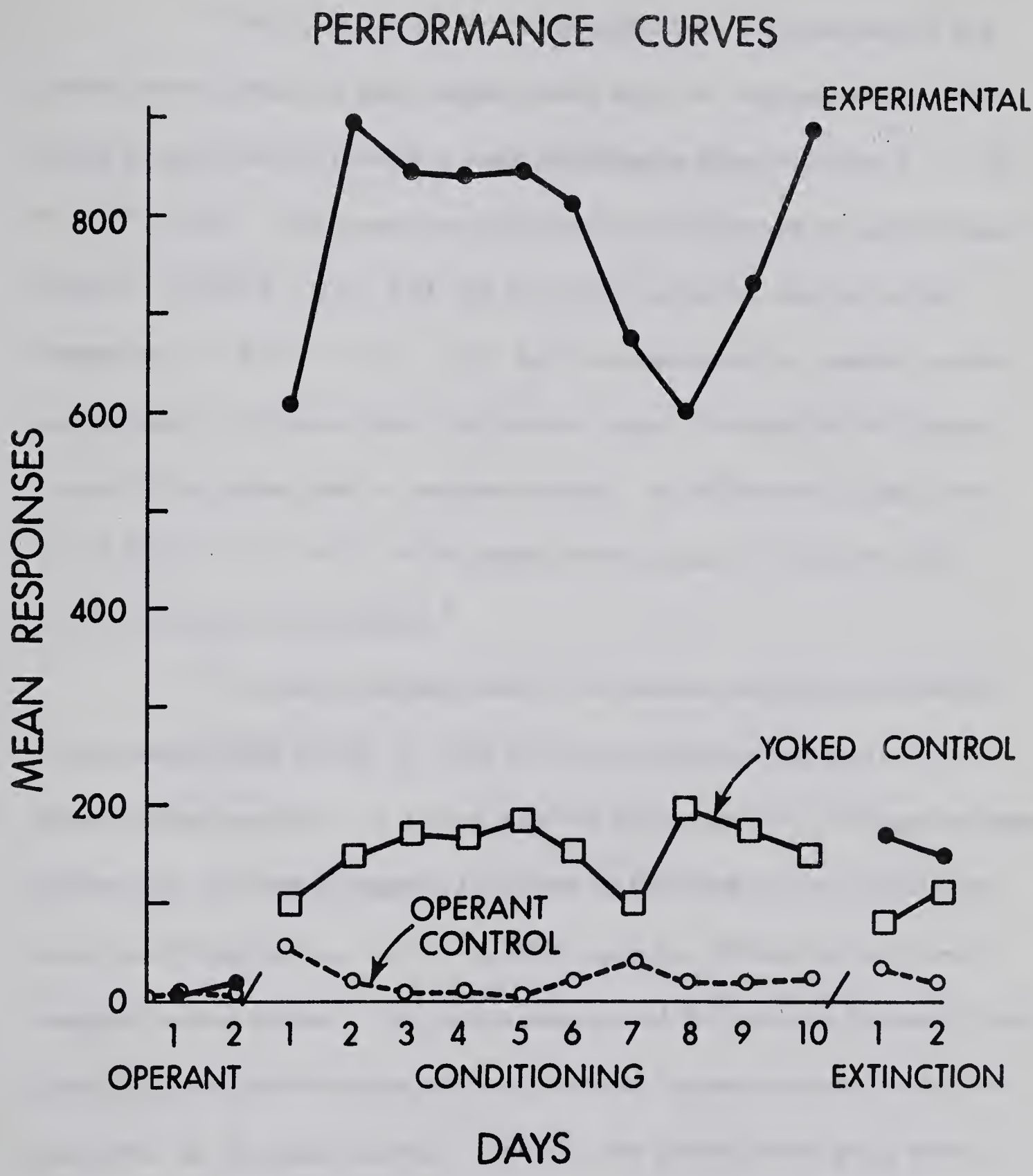


Fig. 8. Mean daily performance of experimental, yoked, and operant groups.

Finally, during the extinction phase both the experimental and yoked control groups are again approximately equal on response output, there being no significant difference in mean performance between groups ($t = 1.728$, $\alpha = .05$, 14 df). Both groups are significantly above the operant control group level ($t = 4.798$, $\alpha = .01$, 14 df, for the yoked control vs. operant control comparison; $t = 6.91$, $\alpha = .01$, 14 df, for the experimental vs. operant control comparison). It is also evident that response output is higher for both groups in the extinction phase than in the operant stage. This difference is significant ($t = 7.074$, $\alpha = .01$, 14 df, for the experimental group; $t = 2.523$, $\alpha = .05$, 14 df, for yoked control group).⁴

The relative effectiveness of the various response contingencies is also demonstrated in Fig. 9. Here the mean cumulative response output is shown plotted over days. It is clear from this graph that during the operant stage of the study, the rate of response (indicated by the slope of the curve) is the same for all three groups. In the conditioning phase, differences in rate-of-response become evident. The greater steepness of the curve for the conditioning group indicates that the average latency between responses was shorter for this group than for the yoked control. Similarly, the yoked control group shows a greater response rate than the operant control group. Finally, Fig. 9 indicates that during extinction the level, but not the rate of performance, is different for the various groups.

⁴See Appendices D and D₁ for tables listing means and statistical comparisons based upon these means.

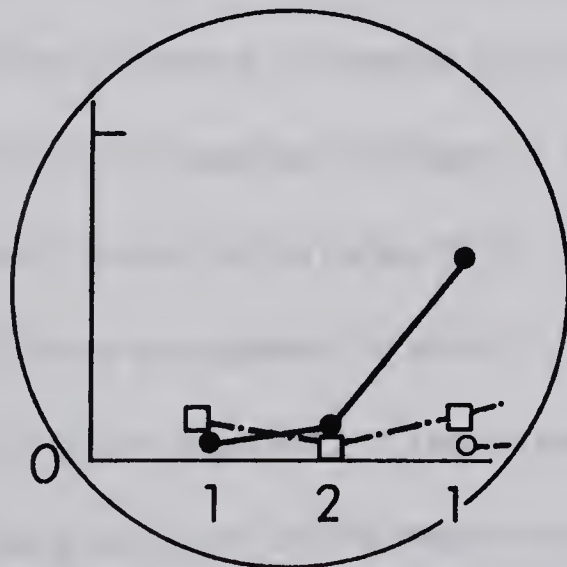
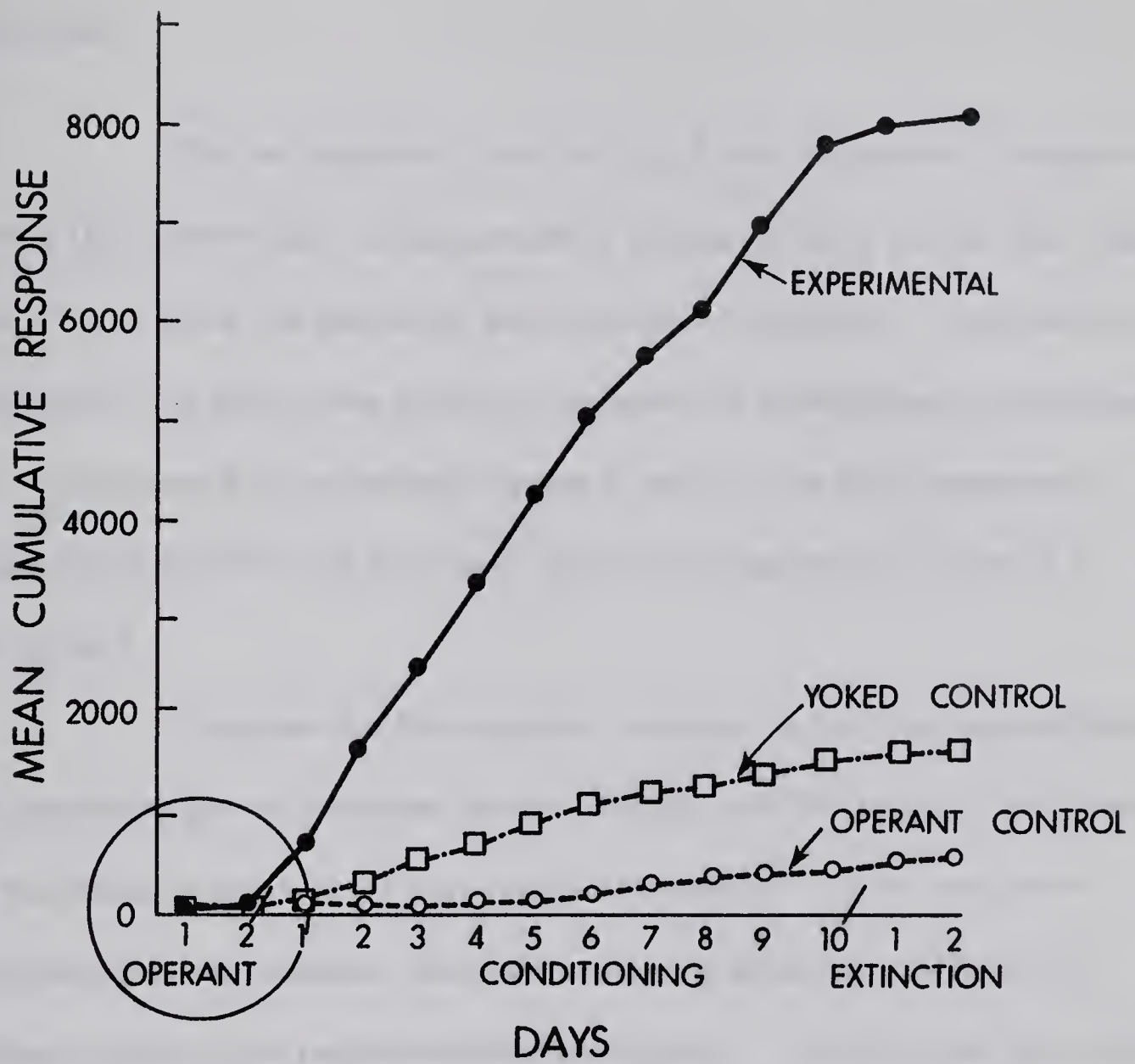


Fig. 9. Mean daily cumulative response output for experimental, yoked, and operant groups. The slope of each curve represents rate-of-response.

Discussion

The two uppermost curves in Fig. 9 show increments in response rate during UCS presentation, increments which are significantly greater than those occurring in either the operant or extinction phase conditions. Two questions now arise: Can both curves be said to represent the development and maintenance of a conditioned (ring swimming) response? and, Do the data represented by these curves establish that the stimuli which evoke aggression can act as a reinforcer?

To answer the first question, consider the fact that large differences in response output exist between groups. Ideally, this difference is attributable to the selective operation of some treatment condition. In the case under consideration, the treatment condition supposedly effecting a difference in response output is the response-reward contingency. The data show that where the acquisition of reward is response contingent, response output is greater than where reward is not response contingent. Since by definition (Ferster and Skinner, 1957), operant conditioning refers to an increment in response probability resulting from an arrangement in which "... a given reinforcer follows the emission of a given response", it seems reasonable to conclude that the increment in performance exhibited by the response contingent group reflects an underlying learning or conditioning process.

On the other hand, the increment in performance of the non-response contingent group cannot be attributed to operant conditioning since the factors involved in response acquisition are not those which describe operant

conditioning. However, in view of the fact that the UCS was effective in eliciting a (display) response, and in view of the more or less random nature of the reinforcement contingencies received by yoked Ss, it seems reasonable to attribute the accelerated performance of this group to the activating effect of the UCS.

To summarize then, the performance curves of Figs. 8 and 9 show the operation of two factors. The curve showing the lowest level of performance shows the effect of a random activity factor. The curve showing the intermediate level of performance reflects the effects of a heightened state of activity while the curve showing the higher level of performance reflects the operation of both activation and learning. It is probably premature at this time to expect to obtain a better estimate of the effects of learning on performance by partialling out the activity factor since it is not known whether learning and activation interact additively or multiplicatively.

CHAPTER FOUR

Introduction

In the two previous chapters, an attempt has been made to discuss and evaluate certain issues concerning the nature of aggression. One of these issues, viz. that certain classes of aggressive behavior can be categorized as FAPs, and that FAPs in turn may have reward value, was put to experimental verification. In the first part of the present chapter, various methodological issues involved in the aggression-as-reinforcer demonstration are considered at some length, and in the second part, a brief prospectus for future research in this area is offered.

Yoked Control Design

The discussion of the experiment presented at the end of Chapter Three represents a relatively straightforward, standard (Kling, Horowitz, and Delhagen, 1956; Clayton and Savin, 1960; and Zimmerman, 1959) interpretation of the experimental results. Recently however, this interpretation has been criticized in an article by Church (1964) who maintains that experiments utilizing yoked control designs do not exclude the possibility that individual differences in responsiveness to the UCS may be sufficient to account for the supposed effects of the treatment (usually response-reward contingency) condition.

Church rightly points out that in most experimental designs in psychological research, individual differences usually result in a random error component because of the policy of randomly assigning \underline{S} s to groups. However in the yoked control design, the argument is advanced that individual differences may produce a systematic bias in results which is not accounted for by a random error component. The argument, summarized in Table 3, is as follows.

Assume for simplicity that there are only two types of \underline{S} s; those for whom an event, such as UCS presentation, is effective in producing an activation effect and those for whom it is not. There are then four possible alternative experimental results. In case 1, the UCS is equally effective in producing the activation effect for both the experimental and control \underline{S} and therefore no reliable difference in response rate occurs between these \underline{S} s. Case 4 yields similar results since the UCS is equally ineffective in producing activation. In cases 2 and 3 however, differences in response rate may occur between \underline{S} s solely as a function of individual responsiveness to the UCS. In case 2 for example, an experimental \underline{S} that is affected by the UCS is matched with a control \underline{S} that is not affected. In this situation, the experimental \underline{S} will obviously record more responses than its matched control. On the other hand, if the experimental \underline{S} is not affected by the UCS and the matched control is, neither \underline{S} will record many responses because the experimental \underline{S} does not provide enough reinforcements for himself or his matched control. Therefore in three out of the four possible experimental alternatives, either negative results (cases 3 and 4) or results supporting the null hypothesis (case 1) should be obtained. If

TABLE 3

Individual Differences in the
Effectiveness of an Event

| Case | Experimental | Control |
|------|--------------|-------------|
| 1 | Effective | Effective |
| 2 | Effective | Ineffective |
| 3 | Ineffective | Effective |
| 4 | Ineffective | Ineffective |

From Church, R. M. (1964), Psych. Bull., 62(2), 124.

the very improbable assumption is made that in a given study, all Ss in one group are affected by the UCS, and all Ss in the other are not, then the probability, according to Church's model, is .004 that positive results will be obtained with the yoked control design. The untenability of this assumption is evidenced by the overwhelming number of yoked control studies reporting positive results (see Church reference), and by the fact that in such studies randomization procedures are routinely used to reduce the likelihood of such an event occurring.

Biased Sampling

Consider then what would happen experimentally if the assumptions were granted that the null hypothesis is true, that individual differences do exist between Ss, and that Ss are randomly assigned to groups. Figure 10 shows hypothetical data for 8 Ss randomly assigned to groups in each of four repetitions of the yoked control design. For purposes of convenience, an average of 500 daily responses is arbitrarily chosen as the response output produced by an S affected by the UCS, while an average of 150 daily responses is arbitrarily chosen as the response output produced by Ss relatively unaffected by the UCS. This assignment of response output seems reasonable in view of the results obtained in Experiment II, and in view of the very tenable opinion expressed by Church that, "... it is more reasonable to assume that the degree to which an S will be affected by an event is a continuous (as opposed to a discrete) variable." (p 124).

HYPOTHETICAL DATA FOR A YOKED CONTROL EXPERIMENT

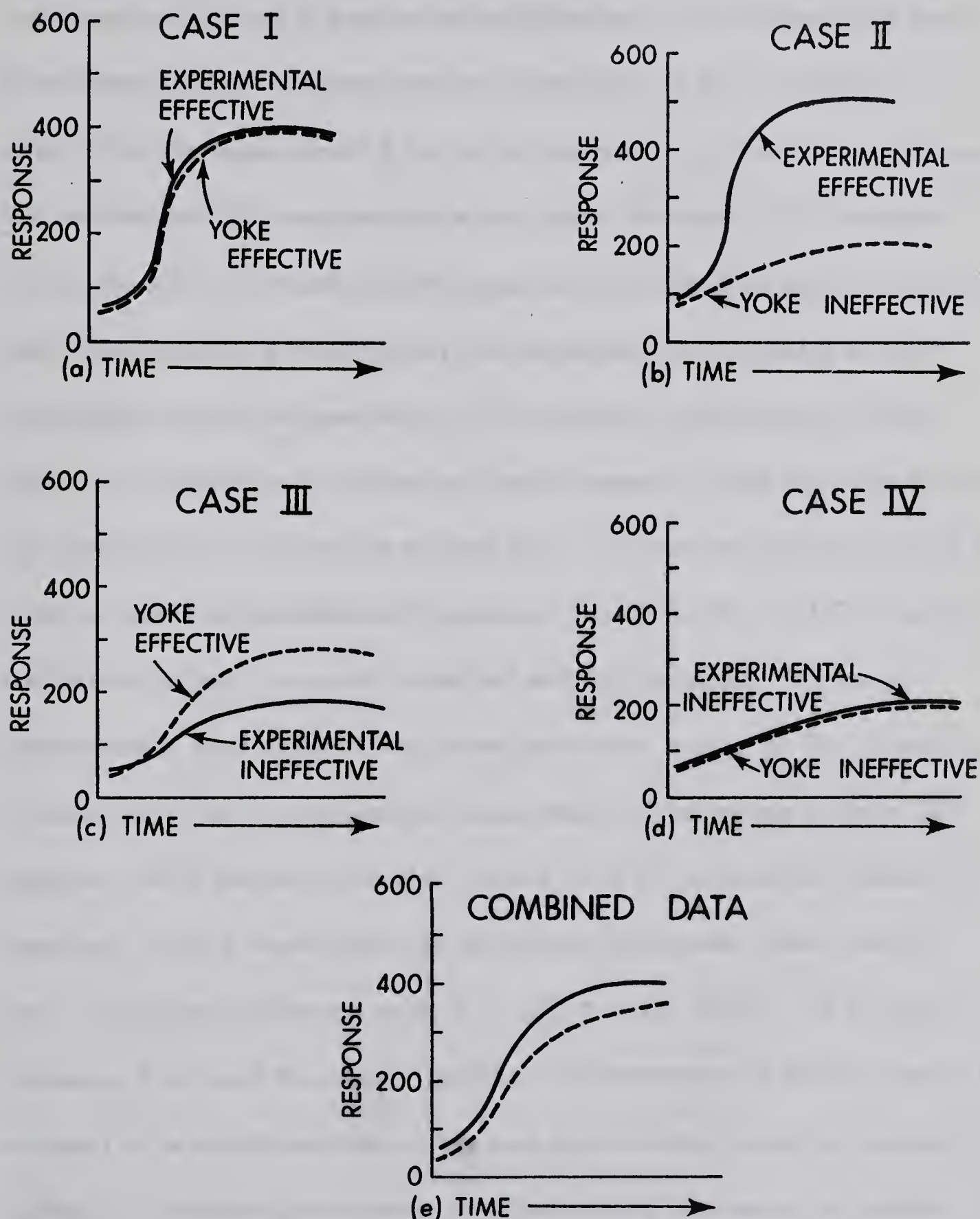


Fig. 10. In a, b, c, and d, are shown the expected levels of performance for S_s affected (500 responses/day) and relatively unaffected (150 responses/day) by the UCS. In e, the mean daily response output is shown for each group. Note that the control group compares favorably with the experimental group on response output.

In part (a) of Fig. 10, the UCS is equally effective for both Ss and consequently these Ss show an activation effect in which an average level of performance at 500 responses per day is attained. In (b), the UCS was effective for the experimental S but not for the control, so that the experimental S is credited with 500 responses while the control obtains only 150 responses. In (c), the UCS is ineffective for the experimental S and effective for the control and although neither S receives many reinforcements, the control S exhibits more responses than the experimental S because each reinforcement is more effective in maintaining a heightened state of arousal. Under these circumstances, the experimental S receives the minimal daily 150 responses while the control is credited with an intermediate 300 responses. Finally in (d), the UCS is equally ineffective for both Ss so each is credited with 150 responses. If the mean performance of each group is then plotted over time, part (e) of Fig. 10 results. It can be seen that the experimental group reaches an asymptote at about 325 responses, while the control reaches a stable level of performance at about 275 responses. Using a two-tailed *t*-test for differences between means, we find that no significant difference exists ($t = 1.72, \alpha = .05, 38 \text{ df}$). Of course, by increasing the size of the sample significant differences would be obtained, but the point to be established here is that most experimenters would be necessarily cautious in interpreting such results as differentiating between an activation and learning hypothesis.

This same point may be established another way. In our discussion of yoked control designs we have explicitly assumed that individual differences

exist in the effectiveness of an event in eliciting certain behavior. Clearly, as the previous example suggests, the magnitude of this difference is the crucial factor in determining whether or not we shall reject the null hypothesis. However, if we assume that the effectiveness of a certain event in producing response output is distributed normally over a population of S_s , then if we have randomly assigned members of this population to groups, we would not expect to reject the null hypothesis unless the initial differences between groups were very large. In short, the only way to establish clear-cut differences between groups and falsely reject the null hypothesis (Type I error) would be to have a biased sample.

The Assumption of Large Individual Differences

A second possible fallacy in Church's reasoning involves the effect of supposedly large individual differences in responsiveness to the UCS. In relation to the present thesis, the argument would run that the visual image of a male Siamese Fighting Fish greatly affected S_s in the experimental group but only minimally affected S_s in the control. That is, the amount of reward (as opposed to the absolute number of reinforcements) received by S_s in the experimental group was greater than the amount received by the controls. Therefore, because of the small amounts of reinforcement and the limited number of trials received, the S_s in the yoked control were unable to learn the response. Presumably by extending the number of reinforcements learning would eventually occur.

This argument however, fails on two counts. First, it is well established that the amount of reinforcement has no effect on the rate at which S approaches the final level of performance (Crespi, 1942, 1944; Zeaman, 1949; Maher and Wickens, 1954) though clear differences in rate-of-response do exist between the groups used in this study (Fig. 9).

Secondly, it seems unlikely that increasing the number of reinforcements for the yoked group would ever have eventuated in conditioning since Ss in this group received, on the average, about 7800 reinforcements in the ten-day test period.

In view of these considerations it would appear that the difference in performance between the experimental and yoked control groups is the result of the response-reinforcement contingency and not the result of individual differences in responsiveness to the UCS. Therefore, the fact that learning can be said to occur demonstrates first that aggression can act as reinforcement for Siamese Fighting Fish and secondly, that Siamese Fighting Fish will actively seek out situations in which to be aggressive.

A Misconception About the Function of a Reinforcer

An important objective of this thesis was to demonstrate that aggression could act as a reinforcer. In order to do this we followed Thompson, and used the operational definition of a reinforcer as an anchor on which to evaluate results. Operationally, a reinforcer is, according to Deese (1958),

"any stimulus event that will increase or maintain the strength of a response or stimulus-response connection associated with it" (p 16). Typically investigators have felt that if learning could be demonstrated with the use of a particular stimulus event, the event could be classed as a reinforcer. Unfortunately, the same researchers have also believed that if learning could not be demonstrated with a particular stimulus event, then that event could probably not be classed as a reinforcer. Such reasoning is unfortunate because it misses the issue of what is involved in reinforcement. Reinforcement by definition involves the notion of an increase in response probability. Such an increase may be reflected in more than one form (Fig. 11). Under certain specified conditions reinforcement may result in learning while under less well defined conditions the same reinforcement may function as an activator. In both cases, however, there is an increase in response probability and this is a sufficient condition (by definition) to establish the reinforcing properties of a stimulus event. In other words, it is not necessary to determine whether learning has occurred in order to establish the reinforcing properties of a stimulus. Church's criticism of the yoked control design fails again on this count because he implicitly assumes that the validity of a particular stimulus event as reinforcer depends upon making a learning-activation distinction.

MULTIPLE OUTCOMES OF REWARD

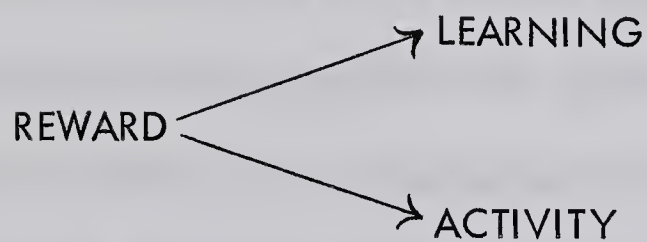


Fig. 11. Diagram Showing the Multiple Outcomes of Reward. Both Learning and Activity may be Reflected in an Increase in Response Probability. Either Outcome, However, Establishes the Reward Value of the Stimulus Event in Question.

Prospects for Future Research

Aggression as a Need to be Satisfied

At this point it is appropriate to emphasize what has thus far been implicit in our treatment of aggression, namely that aggression has been viewed both as a stimulus and, closely related to this, as an energizer or activator of behavior. The time now seems ripe to ask whether aggression also corresponds to some internalized state of the organism which "seeks" satisfaction. This of course is tantamount to asking whether aggression has drive properties. If this turns out to be the case, it should be possible to demonstrate increases in some measure of response strength as a function of response deprivation. Such a demonstration represents the next step in the author's work on aggression. Briefly, the demonstration of the kind specified, involves conditioning Siamese Fighting Fish to some criterion of performance and then depriving Ss of contact with the conditioning apparatus for varying time intervals. Subjects under low levels of deprivation should show longer latencies in rate-of-response than Ss under greater deprivation levels.

Interspecies Validity

The two studies reported by Thompson, and the one reported here establish that the stimuli which evoke aggressive behavior can act as reinforcers in Siamese Fighting Fish and Fighting Cocks. Recently, Arzin (1965) has shown

that the stimuli which evoke aggression in squirrel monkeys can also act as a reinforcer. Since stimuli which evoke aggression have been shown to operate as reinforcers for such a wide range of animals it seems likely that a similar situation would be found to exist in man. An experiment, or perhaps series of experiments, which attempts to evaluate the validity of this proposition would probably represent the next major step in research on aggression.

Summary

Using a modification of a procedure developed by Thompson, an attempt was made to repeat the demonstration that the stimuli which evoke aggressive behavior in Siamese Fighting Fish could act as a reinforcer of a learned response. The results obtained with a control group, used to account for the excitatory effect of the UCS (mirror image of male Siamese Fighting Fish), made it evident that instrumental learning could not be said to occur under the conditions specified. Failure to obtain evidence for conditioning was attributed on the one hand, to the short duration (15 min.) of the daily training sessions, and on the other, to emotionality presumably generated by the netting and shield raising procedures.

A more exact repetition of the aggression-as-reinforcer demonstration, again using a control to account for the excitatory effect of the UCS, substantiated the finding that stimuli which are capable of initiating aggressive behavior can act as reinforcers. It was pointed out however, that the validity

of a stimulus as reinforcer does not depend upon making a learning-activation distinction. However, evaluation of the data suggested that learning had in fact occurred and it was subsequently concluded that the stimuli which evoke aggression in Siamese Fighting Fish could act as a reinforcer, and that Siamese Fighting Fish actively seek out specific situations in which to be aggressive.

Finally current criticisms of the yoked control design were discussed and a hypothetical example of an experiment based upon these criticisms was presented. The outcome of this hypothetical experiment suggested clearly that rejection of the null hypothesis was dependent upon an assumption of very large individual differences between Ss. Consequently the results of this example, together with other arguments advanced, showed that differences between the yoked and experimental groups could not be reasonably attributed to an initial differential excitatory effect of the UCS.

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APPENDIX A

RESPONSE OUTPUT AND WATER TEMPERATURE FOR INDIVIDUAL S_s
(EXPERIMENT I)

GROUP A - REWARD RESPONSE CONTINGENT

| DAY | S ₁ | | S ₂ | | S ₃ | | S ₄ | | S ₅ | | S ₆ | |
|-----|----------------|----|----------------|----|----------------|----|----------------|----|----------------|----|----------------|----|
| | R | T | R | T | R | T | R | T | R | T | R | T |
| 7 | 3 | 82 | 2 | 82 | 2 | 82 | 20 | 82 | 1 | 82 | 0 | 82 |
| 8 | 2 | 81 | 1 | 81 | 2 | 81 | 25 | 81 | 0 | 81 | 1 | 81 |
| 9 | 8 | 80 | 2 | 80 | 7 | 80 | 3 | 80 | 1 | 80 | 0 | 80 |
| 10 | 8 | 82 | 2 | 84 | 6 | 82 | 1 | 82 | 0 | 83 | 0 | 82 |
| 11 | 4 | 84 | 1 | 84 | 4 | 84 | 22 | 84 | 1 | 84 | 0 | 84 |
| 12 | 7 | 82 | 3 | 82 | 1 | 82 | 20 | 82 | 0 | 82 | 5 | 82 |
| 13 | 10 | 83 | 2 | 83 | 0 | 83 | 2 | 82 | 1 | 82 | 2 | 83 |
| 14 | 8 | 82 | 1 | 82 | 2 | 84 | 13 | 82 | 0 | 84 | 0 | 84 |
| 15 | 3 | 83 | 1 | 82 | 3 | 82 | 12 | 83 | 1 | 82 | 2 | 82 |
| 16 | 7 | 83 | 0 | 83 | 0 | 83 | 3 | 83 | 0 | 83 | 1 | 83 |
| 17 | 9 | 81 | 0 | 81 | 0 | 81 | 5 | 81 | 1 | 81 | 3 | 81 |
| 18 | 2 | 80 | 1 | 80 | 2 | 80 | 3 | 80 | 1 | 80 | 0 | 80 |
| 19 | 4 | 79 | 1 | 79 | 1 | 79 | 4 | 79 | 0 | 79 | 0 | 79 |

R = Response

T = Temperature

APPENDIX A₁

RESPONSE OUTPUT AND WATER TEMPERATURE FOR INDIVIDUAL S_s
(EXPERIMENT I)

GROUP B - RANDOM REINFORCEMENT

| DAY | S ₇ | | S ₈ | | S ₉ | | S ₁₀ | | S ₁₁ | | S ₁₂ | |
|-----|----------------|----|----------------|----|----------------|----|-----------------|----|-----------------|----|-----------------|----|
| | R | T | R | T | R | T | R | T | R | T | R | T |
| 7 | 12 | 82 | 0 | 82 | 0 | 82 | 5 | 82 | 0 | 82 | 4 | 82 |
| 8 | 16 | 81 | 0 | 81 | 3 | 81 | 7 | 81 | 0 | 81 | 9 | 81 |
| 9 | 12 | 80 | 0 | 80 | 3 | 80 | 0 | 80 | 1 | 80 | 2 | 80 |
| 10 | 10 | 82 | 0 | 83 | 0 | 82 | 3 | 83 | 0 | 82 | 6 | 82 |
| 11 | 18 | 85 | 0 | 84 | 2 | 84 | 3 | 84 | 0 | 84 | 3 | 84 |
| 12 | 23 | 82 | 0 | 81 | 0 | 82 | 3 | 82 | 0 | 81 | 8 | 82 |
| 13 | 17 | 83 | 0 | 83 | 0 | 83 | 2 | 83 | 4 | 83 | 0 | 83 |
| 14 | 18 | 82 | 0 | 82 | 4 | 83 | 5 | 82 | 0 | 82 | 0 | 84 |
| 15 | 8 | 83 | 1 | 82 | 5 | 83 | 3 | 82 | 1 | 82 | 5 | 82 |
| 16 | 9 | 83 | 0 | 83 | 5 | 83 | 3 | 83 | 0 | 83 | 0 | 83 |
| 17 | 15 | 81 | 0 | 81 | 7 | 81 | 1 | 81 | 0 | 81 | 0 | 81 |
| 18 | 5 | 80 | 0 | 80 | 1 | 80 | 3 | 80 | 0 | 80 | 0 | 80 |
| 19 | 4 | 79 | 0 | 79 | 2 | 79 | 1 | 79 | 0 | 79 | 1 | 79 |

R = Response

T = Temperature

APPENDIX B

OPERANT, CONDITIONING AND EXTINCTION RESPONSES
FOR INDIVIDUAL Ss (EXPERIMENT I)

| SUBJECT | NO. OPERANT RESPONSES | NO. CONDITIONING RESPONSES | NO. EXTINCTION RESPONSES |
|---------|--------------------------|-------------------------------|-----------------------------|
| 1 | 5 | 26 | 0 |
| 2 | 0 | 6 | 0 |
| 3 | 0 | 52 | 0 |
| 4 | 0 | 34 | 0 |
| 5 | 3 | 49 | 4 |
| 6 | 0 | 46 | 0 |
| 7 | 7 | 96 | 6 |
| 8 | 7 | 172 | 1 |
| 9 | 0 | 1 | 1 |
| 10 | 0 | 242 | 4 |
| 11 | 3 | 10 | 2 |
| 12 | 3 | 17 | 0 |

APPENDIX C. DAILY RESPONSE OUTPUT FOR ALL GROUP MEMBERS (EXPERIMENT II)

| DAY | SET ONE | | | | SET TWO | | | | SET THREE | | | | SET FOUR | | | |
|-----|---------------------|------|---------------------|-------|---------------------|------|---------------------|------|---------------------|-------|---------------------|------|---------------------|------|---------------------|-------|
| | NUMBER OF RESPONSES | | NUMBER OF RESPONSES | | NUMBER OF RESPONSES | | NUMBER OF RESPONSES | | NUMBER OF RESPONSES | | NUMBER OF RESPONSES | | NUMBER OF RESPONSES | | NUMBER OF RESPONSES | |
| | EXPER | YOKE | OPER | EXPER | YOKE | OPER | EXPER | YOKE | OPER | EXPER | YOKE | OPER | EXPER | YOKE | OPER | EXPER |
| 1 | 17 | 12 | 0 | 14 | 34 | 18 | 11 | 17 | 7 | 16 | 2 | 15 | | | | |
| 2 | 50 | 27 | 20 | 30 | 28 | 13 | 9 | 28 | 5 | 29 | 1 | 5 | | | | |
| 1 | 403 | 117 | 26 | 133 | 240 | 72 | 847 | 6 | 24 | 1120 | 3 | 125 | | | | |
| 2 | 993 | 114 | 14 | 296 | 408 | 0 | 1003 | 11 | 22 | 1289 | 3 | 43 | | | | |
| 3 | 1058 | 194 | 0 | 300 | 322 | 1 | 515 | 20 | 7 | 1598 | 140 | 16 | | | | |
| 4 | 1013 | 104 | 5 | 487 | 402 | 1 | 1119 | 8 | 7 | 847 | 124 | 9 | | | | |
| 5 | 934 | 114 | 2 | 715 | 437 | 4 | 885 | 32 | 7 | 953 | 105 | 7 | | | | |
| 6 | 283 | 22 | 11 | 732 | 471 | 9 | 1458 | 9 | 18 | 878 | 108 | 36 | | | | |
| 7 | 563 | 43 | 39 | 382 | 157 | 34 | 806 | 34 | 21 | 1032 | 127 | 60 | | | | |
| 8 | 366 | 62 | 41 | 542 | 411 | 29 | 587 | 15 | 5 | 803 | 237 | 27 | | | | |
| 9 | 385 | 101 | 37 | 801 | 348 | 33 | 938 | 24 | 5 | 860 | 183 | 6 | | | | |
| 10 | 474 | 88 | 10 | 1087 | 291 | 39 | 1190 | 9 | 10 | 781 | 147 | 35 | | | | |
| 1 | 105 | 51 | 28 | 149 | 105 | 29 | 207 | 21 | 48 | 185 | 145 | 31 | | | | |
| 2 | 74 | 53 | 16 | 193 | 77 | 23 | 156 | 17 | 43 | 113 | 259 | 19 | | | | |

APPENDIX D

TABLE OF MEANS FOR EXPERIMENT 11

| GROUPS | | Operant Phase (A) | Conditioning Phase (B) | Extinction Phase (C) |
|------------------|-----|----------------------|---------------------------|-------------------------|
| Experimental (D) | | 22.00 | 786.40 | 147.75 |
| Yoked | (E) | 18.63 | 145.45 | 91.00 |
| Operant | (F) | 10.38 | 22.40 | 29.63 |

APPENDIX D₁

TABLE OF SIGNIFICANT AND NONSIGNIFICANT COMPARISONS
FOR VARIOUS MEAN DIFFERENCES*

| GROUP | PHASE | | | | | | |
|-------|-------|-----|-----|-----|-----|-----|-----|
| | A | B | C | | | | |
| | | | | A-B | A-C | B-C | |
| | | | | | | | |
| D-E | NS | .01 | NS | D | .01 | .01 | .01 |
| D-F | NS | .01 | .01 | E | .01 | .05 | NS |
| E-F | NS | .01 | .01 | F | NS | .01 | NS |

- A = Operant Phase

B = Conditioning Phase

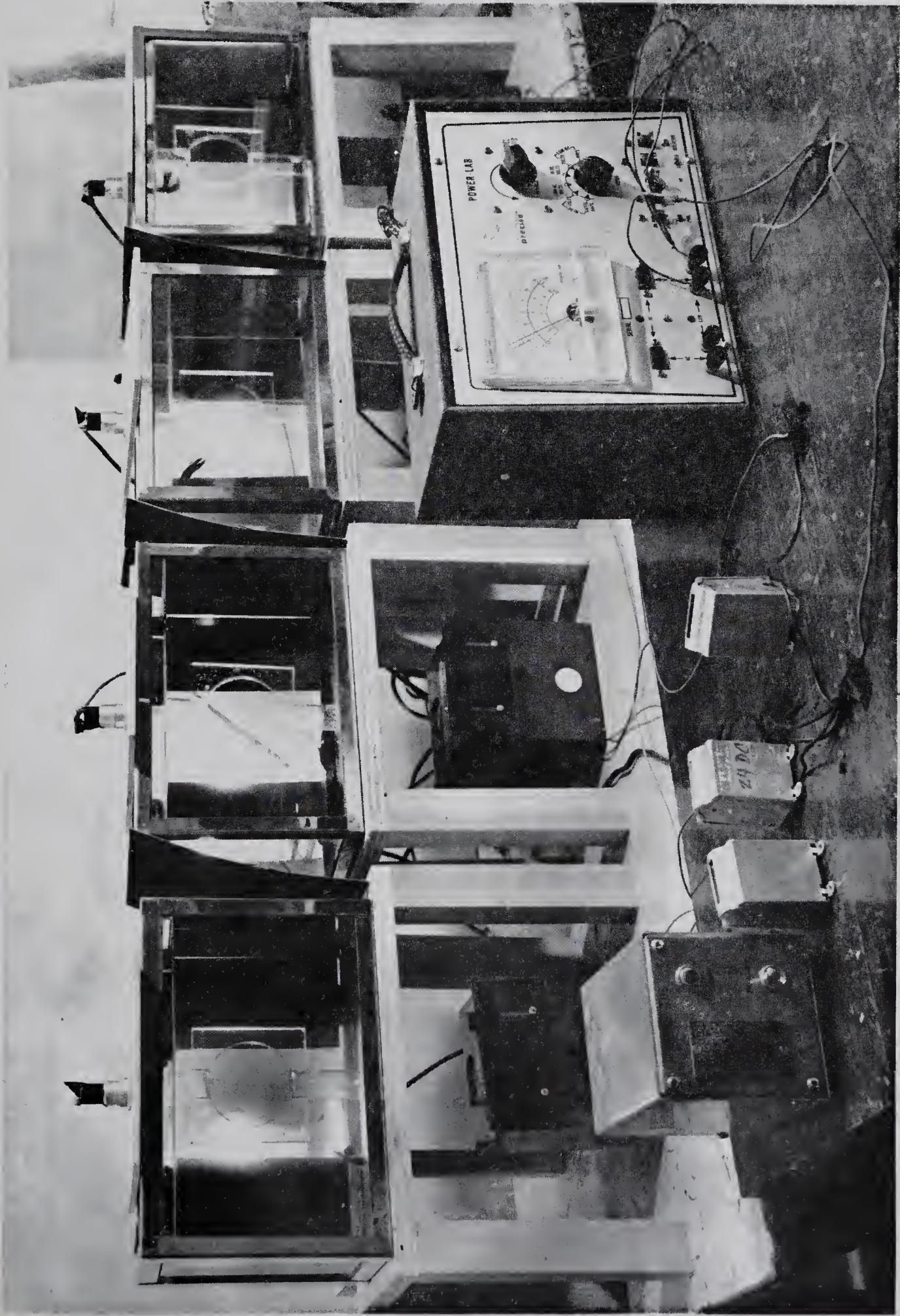
C = Extinction Phase
- D = Experimental Group

E = Yoked Control Group

F = Operant Control Group

* Based on data of Appendix D

APPENDIX E



Photograph of Operant Control Equipment (Experiment II)

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